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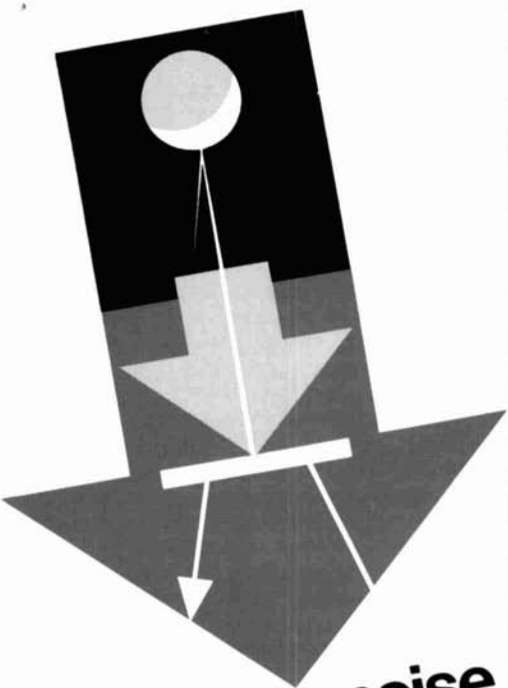

ultra low noise uhf preamplifier

this month

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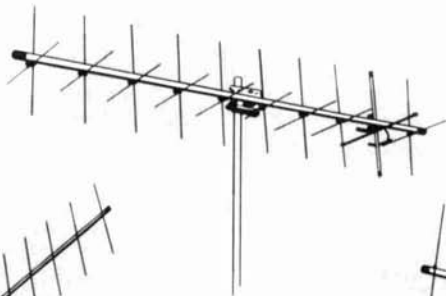

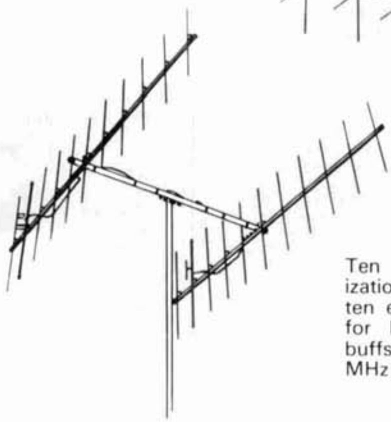

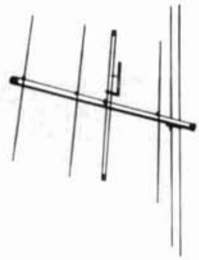

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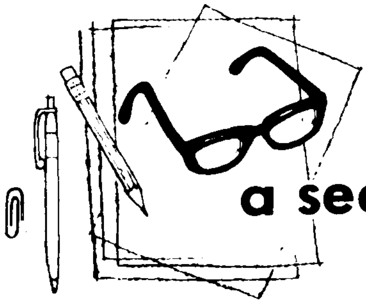


a second look

by jim fisk

Two of the major semiconductor manufacturers are working on new families of bipolar digital logic that may do as much to revolutionize the computer world as anything in the past. Texas Instruments, for example, has developed a new family of Schottky logic, called Schottky II, with 1-to-2-nanosecond delays (compared to 10 nanoseconds or so for TTL) which operates from a single 5-volt power supply, offers better performance than today's ECL 10k and is provided in standard, easy-to-use pinouts. Unfortunately, because of the dismal market conditions which are facing the semiconductor manufacturers just now, it may be months before Schottky II is available to designers.

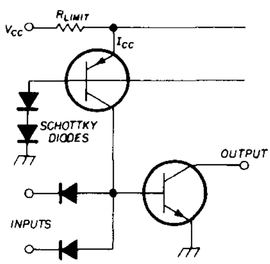
Although not a great deal is known about Motorola's new bipolar logic family, it is known to feature 1-to-2-nanosecond delays and will be compatible with ECL 10k. However, they have been working with a system of complementary constant-current logic (C^3L) with 1-nanosecond delays (and 1 mW per gate) that could provide the necessary performance. Motorola is also rumored to be working on a family of sub-nanosecond logic called ECL 100k that should provide some answers for digital designers who are looking for faster and faster computers.

The complementary constant-current logic is particularly interesting because it combines the best of several worlds not previously available on one chip: very high speed, high packaging density and low power consumption. The high packing density of C^3L is due to its very simple transistor-gate structure, shown below, which consists only of a pnp current source transistor, an npn switching transistor and a few Schottky barrier diodes. By way of contrast, the Schottky TTL gate uses four transistors, plus diodes.

Because of the simple structure, a five-output gate requires only 12 square mils (0.008 square mm). By comparison, a low-power cmos circuit of the same complexity requires about 65 square mils (0.04 square mm) of chip space. This high packaging density means that a 1000-gate C^3L array could be placed on a 150-by-150-mil (4x4mm) chip.

While you may be hard put to think up an application in your amateur station for a 1000-gate logic array, many traditional analog circuits (TV tuners, for one) have gone the digital route in recent years, and other devices, such as frequency synthesizers, small hand-held calculators and digital meters, would never have seen the light of day in an all-analog world. If the past is any indication, future digital applications will have an even far wider effect.

Jim Fisk, W1DTY
editor-in-chief



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WWV/WWVH PROPOSE CUTBACK in services, solicit advice from users. Write Time and Frequency Services, National Bureau of Standards, Boulder, Colorado 80302 for detailed questionnaire.

BICENTENNIAL CALLSIGNS pretty well set, will use only AA-AL prefix block to cover both continental and offshore W and K prefixes during 1976 celebration. Though stateside bicentennial prefixes will use present numbers to indicate call areas, look for some real odd balls for such things as Alaskan Novices...

220-MHZ CLASS-E CB still very much a threat -- recent letter from OTP Acting Director Eger to FCC Chairman Wiley urges giving "every consideration" to "expeditious action" in granting Class-E 222-224 MHz! The letter cites the need for a "disciplined" citizen's communications service, half-billion dollar a year market, gives lip service to value of amateur service -- and would let us continue to use the new CB band, with limitations! Class E could start up as early as May!

GOVERNMENT AGENCY SHAKES ANTENNA TOWERS -- OSHA, the occupational safety people, want all towers over 20 feet to have a built-in OSHA-approved ladder (16-18" wide, with side rails mounted 6" off the tower)! Since the OSHA ladder is heavier than most light-duty amateur and TV antenna towers, such a requirement would have a great effect on tower prices. Ruling would become effective this summer barring protests, but look for lots of those from users and makers alike.

ARRL DIRECTORS' MEETING in January confirmed Dick Baldwin, W1RU, as League General Manager and QST editor to replace John Huntoon. Dick took over February 1, while John continues as both ARRL and IARU Secretary.

Docket 20282 Discussion occupied much of the Directors' time, resulted in authorization of a "membership opinion survey" to be conducted on the Division level. Survey will be made in time for individual directors to consider results before a special board meeting in May when League response will be determined.

NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 appears likely to have little direct impact on amateur radio, but indirect effect on the unwary may cause lots of bother. Environmental impact report must be filed with amateur license applications on Form 610 or 610B only if the station will have a "major" impact on the environment. Installations having a "major" impact are: Antenna towers or antennas over 300 feet high (but not an antenna mounted on an existing structure 300 or more feet high); satellite earth stations with dishes of 30 feet or more in diameter; locations in a wilderness area, wildlife preserve or national scenic or recreation area; stations affecting sites significant in U.S. history; and any involving extensive changes in land-surface features.

Applications Other Than The Above are considered "minor" and no statement need be filed. However, to be on the safe side, until new forms are available, add a statement such as, "This application is a 'minor action' as defined by Section 1.1305 of the Commission's rules." somewhere on the form unless you will have a "major" environmental impact, in which case a call to the FCC is advisable.

NEWLY ANNOUNCED HAND-HELD CALCULATORS, as promised in January editorial, offer more performance for less cost. New HP-21 Scientific from Hewlett-Packard ($125) is more powerful than HP-35 and features 32 pre-programmed functions including rectangular/polar conversion, while new programmable HP-55 ($395) provides 49-step programming and 86 keyboard functions. Also new are Novus Mathematician ($80) and 10-digit Corvus 500 ($200).

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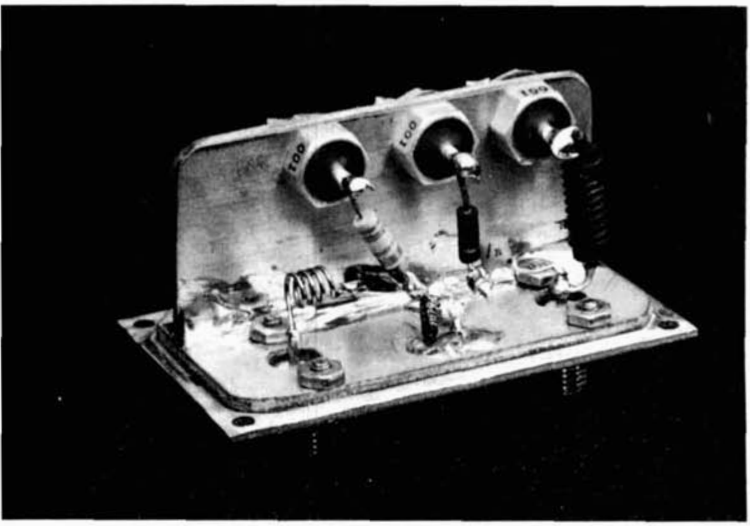


ultra low-noise uhf preamplifier

Design and construction of an ultra low-noise preamplifier with a 1.0 dB noise figure at 432 MHz that provides high performance on 144 and 220 MHz as well

Joseph H. Reisert, Jr., W1JAA, Chelmsford, Massachusetts 01801

There is always a need for a better preamplifier with a lower noise figure and higher gain. Such a preamplifier was introduced in November, 1972.[1] This preamplifier took up the slack after the TIXM05 disappeared and the low-noise fets bottomed out, and it introduced several new features to amateur radio including state-of-the-art noise figure, wide bandwidth, low-Q input, current-source biasing and built-in limiter. In addition, it required no tuning.

Since the original preamplifier was introduced, an improved version has been developed. This new preamplifier has higher gain, lower noise figure, and an improved biasing scheme while embodying all the other features mentioned above. It has been duplicated by over twenty-five individuals throughout the world and is the input preamplifier used at most of the 432-MHz EME stations. Two of the die-hard paramp users now have models of these preamplifiers in use. It meets or exceeds their paramp performance and is easily mounted at the antenna, a feature not easily duplicated with paramps and their associated pumps.

requirements for low noise figure

A low-noise-figure transistor is required in the circuit but it is not the only requirement for a low-noise-figure preamplifier. Other requirements include proper operating current and voltage, optimum source impedance, low-loss matching circuits, low feedback, moderate gain and good stability, to mention a few. Let's discuss these requirements separately.

The need for a low-noise-figure transistor should be obvious. You cannot attain a noise figure which is lower than the device is capable of delivering due to other factors affecting the design. You will be lucky, at best, if you end up within 0.25 to 0.5 dB of the device's capability.

Joe Reisert, W1JAA, was first licensed in 1951 as WN2HQL, and in 1956 earned his Extra Class license. He moved from Long Island to San Jose, California, in 1961, where he was licensed as WA6TGY, later as W6FZJ. He attained the DXCC Honor Roll in 1968 and presently stands at 330 confirmed. In the late 1960s he became interested in uhf, had his first 432-MHz contact in 1970, and put his EME station on the air in 1972. Before moving to Massachusetts last spring he had worked nine states on 432 MHz from California plus Canada and Australia. He is joint holder of the 2304-MHz tropo DX record of 330 miles set in February, 1974, and is active from Massachusetts on 432-MHz EME. Primary amateur interests are DX, EME, and antenna and receiver design.

Joe was formerly the supervisor of Microwave Product Engineering at Fairchild Microwave after working at Sperry, IBM, Lockheed and Wescom Microwave, and is presently manager of Microwave Applications Engineering at Alpha Industries, Inc., in Woburn, Massachusetts — a leading manufacturer of microwave diodes.

The collector current (I_C) and collector-to-emitter voltage (V_{CE}) are also prime considerations. Generally, V_{CE} is not too important if it is greater than 6 volts. Lower V_{CE} generally lowers the collector cutoff frequency (f_T) and hence, the gain. The collector current, on the other hand, is very important. Older devices were usually optimum with 1.0 to 1.5 mA collector current. The newer devices, as a rule, work best at 2 to 3 mA collector current and their noise figures do not degrade as fast as their predecessors' at higher collector currents (more on this later).

The optimum source impedance is the impedance that the transistor wants to see in order to deliver the lowest possible noise figure. At frequencies below 1000 MHz this value is seldom 50 ohms. Therefore, a matching network is usually necessary between the antenna input and the transistor. This network must have very low loss since any losses will add directly to the overall noise figure of the preamplifier.

In addition, low feedback is essential to low-noise operation and feedback will usually raise the noise figure. This also applies to series feedback in the emitter lead. The emitter should be well bypassed to ground to prevent degeneration and higher noise figures. Current-source biasing is preferred since it allows the emitter to be grounded directly without bypassing. A suitable scheme was used in the original preamplifier. This design will include a simpler and less critical circuit.

High gain is essential for low noise performance. If the gain of the preamplifier is not high enough, the overall system noise figure will be degraded due to the noise figure contribution from the second stage. However, if the preamplifier gain is too high it may become unstable or may overdrive the second stage and cause desensitization or intermodulation distortion. A good rule of thumb is to strive for 10 to 13 dB minimum preamplifier gain. Gain above 18 to 20 dB should be avoided since it generally indicates a potential instability. More on this later. A method for computing gain and overall noise figure is discussed further in **appendix 1**.

tradeoffs

Noise figures below 1.5 to 2 dB are usually wasted on meteor scatter and tropo communications. At 144 MHz this is still a low enough noise figure for EME since the sky temperature is usually not much lower than the terrestial temperature. Therefore, a good fet is sufficient to deliver all the performance needed. However, on EME above 420 MHz the sky temperature may be below 70° K, so a lower noise figure is desirable. For example, a 1 dB noise figure preamplifier may yield up to 2 dB better signal-to-noise ratio than a 1.5 dB noise figure unit.

Cost is obviously the most important tradeoff. Low-noise-figure, high performance transistors are expensive. However, in view of the performance gained, it is penny wise and pound foolish to cut corners too closely. Generally speaking, a low-noise transistor suitable for tropo operation up to 450 MHz will cost about $10, and up to $25 for a higher performer. The sky is the limit when it comes to the extremely low noise figures (1.5 dB or less) necessary for EME.

In the preamplifier presented here a device costing less than $50 will outperform just about any device presently available *at any price*. On EME you may spend hundreds, and maybe thousands,

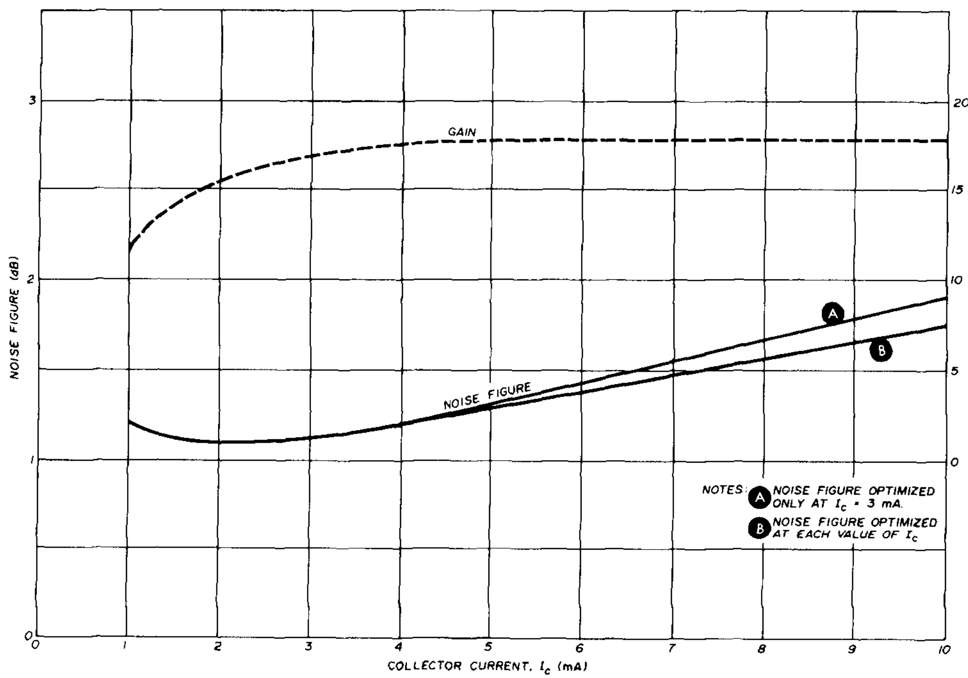


fig. 1. Typical FMT4575 noise figure and gain at 432 MHz vs collector current (V_{CE} constant at 7 volts).

of dollars and hours building a suitable station. Why skimp when it comes to the preamplifier? A suitable performance increase in the antenna may be completely out of the question due to size or money.

Gain isn't everything, but it does help. This is especially true when the preamplifier is remotely mounted. An extra gain margin helps to overcome cable losses. Furthermore, on the more modern low-noise transistors the gain increases quite smoothly when the collector current is increased while at the same time the noise figure may not rise as rapidly as you would expect (see **fig. 1**). As an additional by-product, the intermodulation distortion decreases significantly with increasing I_C. Again, it pays to use a high performance transistor so you can "have your cake and eat it too."

A broadband preamplifier can present some problems since there is little or no discrimination to out-of-band signals. Therefore, an input filter is highly recommended. A suitable type will be discussed in the latter part of this article.

transistor selection

I have evaluated many npn transistors, all with an eye on minimum noise figure and maximum stable gain at 432 MHz. The circuit described in reference 1 used the NEC 2N5650 series (and its offshoots such as the NEC V766). However, a 1.4 dB noise figure was the lowest measured, and stable gain seldom exceeded 13 dB. Other high performance devices which were tried included the Fairchild FMT4225 and Hewlett-Packard HP-21 series. They delivered high gain but higher noise figures (1.5 to 2 dB typical). Likewise, the Amperex BFR90 and BFR91 seldom provided noise figures below 2 dB.

The Fairchild FMT4575/4578 and FMT4000/4005 were true eye-openers; they easily yielded a 1.25 dB noise figure and 1 to 1.1 dB was not uncommon. Since the FMT4000/4005 and 4578 are higher priced and didn't provide better performance, I decided to design a preamplifier around the lower priced FMT4575. At $44 (each) it delivers the most performance per dollar of any transistor presently available and will challenge the best of paramps at 432 MHz.

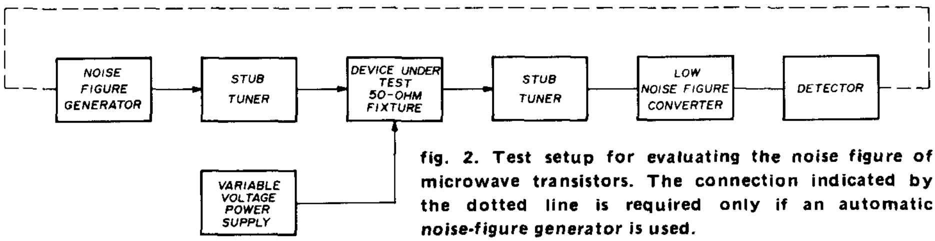


fig. 2. Test setup for evaluating the noise figure of microwave transistors. The connection indicated by the dotted line is required only if an automatic noise-figure generator is used.

For those interested in evaluating their own devices a lab test setup can be built as shown in **fig. 2**. The device to be tested is mounted in a suitable low-loss transistor mounting fixture which includes a 50-ohm input and output line with dc blocks. This mounting fixture is connected between two low-loss double- or triple-stub tuners. A noise-figure generator is connected to the input stub tuner and a very low-noise-figure converter is connected to the output tuner. Then the bias voltage and current are adjusted to predetermined values (per manufacturer's data sheets).

The output tuner is first adjusted for maximum stable gain and then the input tuner is adjusted for minimum noise figure. After optimization the bias points are varied up or down (within manufacturer's ratings) and the tuners are readjusted. This procedure is continued until the lowest possible noise figure is obtained.

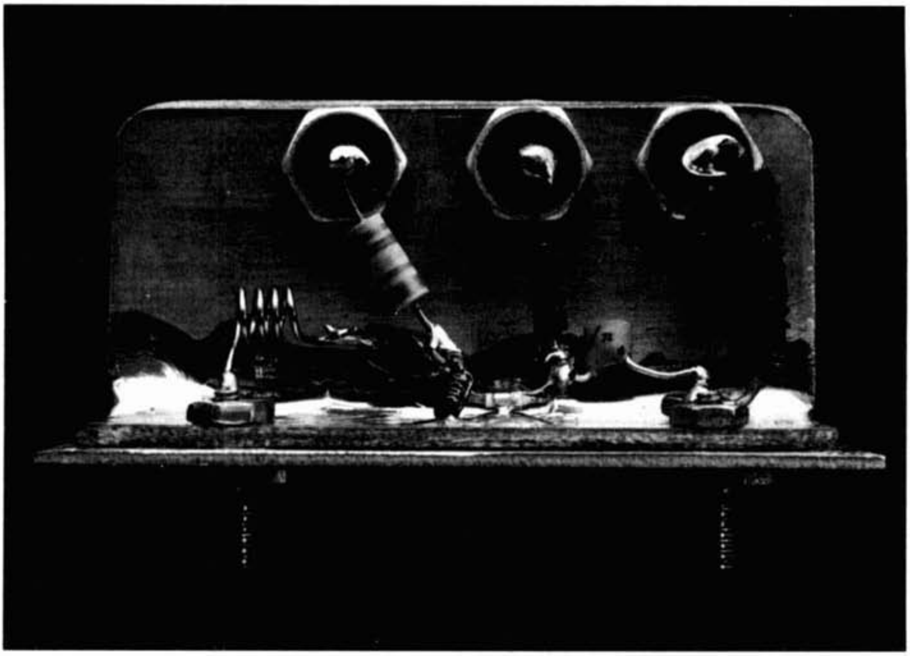
circuit description

While the preamp described here is quite similar to the original design, there are important differences. They are basically the transistor used, the input/output matching and the current source.

The transistor was chosen by the method described above. Then the transistor test fixture was split apart and a low-loss 50-ohm termination was substituted for the noise-figure generator. With the aid of a network analyzer, the desired source impedance was measured. This impedance is called the optimum source impedance as described earlier. In the case of the Fairchild FMT4575, this impedance can be approximated by a series circuit consisting of a 50-ohm resistance and an inductive reactance of 80 ohms (see **fig. 3**).

It so happens that at 432 MHz most of the low-noise transistors evaluated generally required a similar network except that the values varied from 25 to 75 ohms for the resistance and from 30 to 100 ohms for the inductive reactance. These values can be easily simulated by slight changes in the inductance value and by placing a small (0.3 to 3 pF) low-loss variable capacitor either between point X or Y to ground (**fig. 3**). However, this capacitance value is not critical and seldom yielded much improvement in noise figure on the devices I tested.

A low-loss input matching circuit is very important. Therefore, low-loss components should always be used with the least complicated, low-Q circuit.



Construction of the ultra low-noise preamp showing placement of the main components. Components can be identified from fig. 7 on page 17.

This is in direct contrast with previous design philosophy which frequently used filters and/or resonant input circuits. Such circuits can contribute additional losses. *The input of a low-noise preamplifier is a poor place to obtain selectivity*. A better choice is to install a low-loss filter external to the preamplifier as discussed later.

The final input matching circuit chosen was a low-loss, low-Q, L-matching section consisting of L1 and CR1 (**fig. 4**). Capacitor C1 is a blocking capacitor (not a critical value). However, a low-loss, high-Q type is desired. RFC1 is essentially a low-Q parallel-resonant circuit at 432 MHz and therefore is effectively out of the circuit. It actually works quite well from 100 to 450 MHz. Some of the physically larger RFCs available are parallel resonant below 450 MHz and are not recommended. A grid-dip oscillator can be used for a quick test or, you can wind your own choke using a 0.1 to 0.2-inch (2.5 to 5.0 mm) diameter air core. A higher inductance RFC can be used if only lower frequency operation is desired.

Do not leave out the hot-carrier diode, CR1. It is the capacitance part of the L-matching section and adds about 0.75 pF to the circuit. Other hot-carrier diodes can be substituted provided the capacitance is 0.5 to 1.0 pF at zero volt. Do not use ordinary silicon or germanium diodes since they may increase the noise figure.

Diode CR1 also functions as a low-loss limiter and can save the transistor from being damaged if the preamplifier is subjected to excessive rf. Even rf from a high-frequency transmitter operating near a vhf antenna can do damage. This type of limiter is simple and effective. An added advantage is that it is placed after the selectivity. Hence, it will only activate when a strong input signal is present — it *will* not generate extraneous signals such as is common with back-to-back diodes connected across the input of a preamplifier ahead of the selectivity.

The bias scheme is a modification of the current source used in the previous design and is a variation of a method proposed by Fairchild Semiconductor.[2] I refer to it as "zener-diode biasing." It is much simpler than the transistor current-source and is less prone to oscillate. This bias scheme allows the

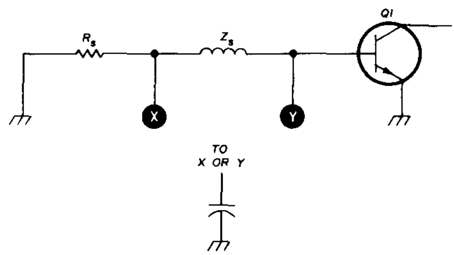


fig. 3. Rf equivalent circuit for an optimum source impedance network as described in the text.

emitter to be grounded directly, is insensitive to transistor current gain, provides some dc protection to the transistor and requires no adjustments.

Fig. 5 is a simplified circuit of the zener-diode biasing scheme. The zener diode, CR2, sets the transistor collector-to-base voltage (V_{CB}), R3 sets the I_C with a fixed supply voltage and R1 provides a keep-alive current flow for CR2. CR2 also provides protection to Q1 and limits the collector voltage to a fixed value. Once the proper values are chosen the transistor can be changed without any re-adjustment. The operation of this circuit is described in detail in **appendix 2**. CR3 (**fig. 4**) is an *idiot* diode (if you leave it out you're an idiot).

The output matching scheme is simplicity in action. This transistor (and many others like it) is so "hot" that all attempts at output matching caused instabilities. A computer program called SPEEDY[3] was called into action and a program was written to select an output network which was unconditionally stable (will not oscillate regardless of input or output load). The final network turned out to be a 37-ohm collector resistor without any other matching elements. However, this lowered the gain too much. It was determined empirically that the collector resistor R2 can be raised to 100 ohms and seldom causes any instabilities. Therefore, if the input to your preamplifier and converter is highly reactive (most are), then the 100-ohm resistor may *have to be lowered accordingly*. This type of loading is also applicable to other preamplifiers which are only conditionally-stable.

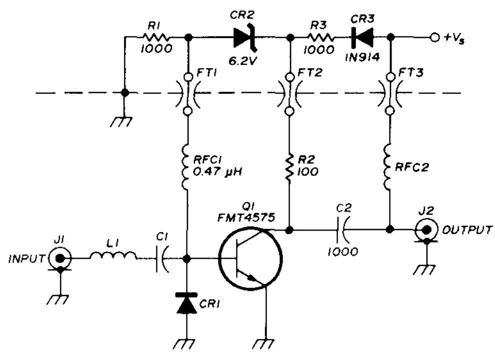
Finally, a simple "bias-tee" consisting of RFC2 in the preamplifier and RFC1 and C1 in the bias tee itself (see **fig. 6**) was added in case remote installation is desired. It not, this circuitry can be eliminated.

construction

Fig. 7 shows the preamp construction and the FMT4575 pin configuration. A small cast aluminum box such as the Pomona 2417 (2.25x1.375x1.125 inches or 57x35x29mm) is recommended. This box is available from most major electronic suppliers for $1.60. However, almost any shielded box is acceptable. The entire preamp is built on a small 1-1/8x2-inch (29x51mm) piece of double-clad glass-epoxy printed-circuit board which is attached to the box cover by the connector screws. If remote installation is not desired, FT3 can be mounted through the PC board and cover for power supply connections. This method of construction is versatile and simplifies soldering and testing. If you use the Pomona box, *be sure to remove the paint where the lid contacts the box. Also file off the anodized coating on the edge of the cover which contacts the box*. Failure to do so may result in erratic operation.

Be sure to check the data sheet for proper connection of any transistor other than the FMT4575. There is no industry standardization for lead identification on microwave transistors. The *emitter lead length on this type of* microwave package is not too critical and 1/8 inch (3mm) is recommended for operation up through 500 MHz. Both emitter leads should be the same length and both should be grounded. The leads of CR1 should be kept as short as possible so that it performs like a capacitor.

The rf connectors should be a good



C1 100-180 pF miniature dipped mica or ceramic

C2 1000 pF miniature ceramic disc CR1

CR1 hot-carrier diode (Hewlett-Packard 5082-2810)

CR2 6.2 volt zener diode (1N4735)

CR3 silicon diode (1N914)

FT1-FT3 feedthrough capacitors, 470-1000 pF

J1,J2 SMA-type coaxial connectors (see text)

L1 4 turns no. 24 on 0.1" (2.5mm) diameter, spaced wire diameter (approximately 30 nH)

Q1 Fairchild FMT 4575 low-noise transistor (*see text*)

R2 100 ohms, 1/4 watt (see text)

RFC1 0.47 µH miniature rf choke (Nytronics SWD=0.47)

RFC2 0.2-0.47 µH miniature rf choke or Ohmite Z-460 (value not critical)

fig. 4. Schematic diagram for the ultra low noise 432-MHz preamplifier. RFC2 is required only if the preamplifier is installed remotely.

uhf type such as SMA (OSM®). Discontinuities in BNC connectors can cause noticeable noise figure increases when operating with such a low-noise-figure device. Type-uhf connectors are definitely unacceptable at 432 MHz. Type N or TNC are also acceptable, but may be too large if a small box is used. An inexpensive version of the SMA connector is manufactured by the E.F. Johnson Company (JCM series, part number 142-0296-001) and is priced under $2.00. The type of output connector is not critical.

operation and test

After the preamplifier is assembled, a careful check of the wiring is recommended. Next, the preamplifier should be connected to a +12 volt power supply through a milliammeter (0 to 10 mA recommended). Terminate the preamplifier with a 50-ohm input and output load if available. If not, connect an antenna and converter to the preamplifier.

For proper operation, the total current should be 3.5 to 5.0 mA. If the indicated current is greater than 5 mA, remove power and recheck circuit wiring. High current usually means either a short circuit and/or improperly connected zener diode. If the power supply is variable, bring the voltage up slowly. At +11 volts, the current will be about 1 mA less than at +12 volts; with a +13 volt supply the current will be about 1 mA higher than at +12 volts. This indicates proper operation of the zener diode biasing circuits.

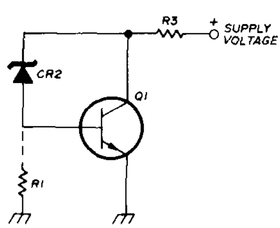
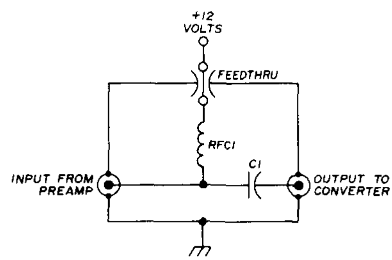


fig. 5. Dc schematic of the zener-diode bias scheme. Typical values are given in appendix 2.

It should not be necessary to make any adjustments. However, if you have sufficient test gear available, adjust the turns spacing on L1 for best noise figure by pulling apart or squeezing. This usually will only vary the noise figure by ±0.1 dB. For those purists who want to get all they can squeeze out of the circuit, an additional 0.3 to 3 pF low-loss piston capacitor can be placed between the input or transistor side of L1 to ground (see **figs. 3** and **4**).

input filter

It is advisable to use a low-loss,



C1	100-200 pF small dipped mica or ceramic capacitor
FT1	470-1000 pF feedthrough capacitor
RFC1	0.3-0.47 μH miniature rf choke (Ohmite Z460)

fig. 6. 432-MHz bias tee for use when the preamplifier is installed remotely is built into a small shielded box. Be sure to keep the leads on capacitor C1 as short as possible.

quarter-wavelength cavity filter ahead of the preamplifier since the simple broadband input circuit may cause intermodulation products from out-of-band signals. A suitable filter is shown on **fig. 8**. It should be connected as close to the preamplifier as possible. This can usually be accomplished with a short coax adapter. Multiple-element filters such as comb-line and interdigital types are not recommended. The input vswr to this, and most other, low-noise preamplifiers is typically 5:1. If a multiple-pole filter is used, it may suffer severe passband ripple due to the high vswr. The net result may be additional loss and, hence, higher noise figure at the operating frequency. It may also cause out-of-band oscillations.

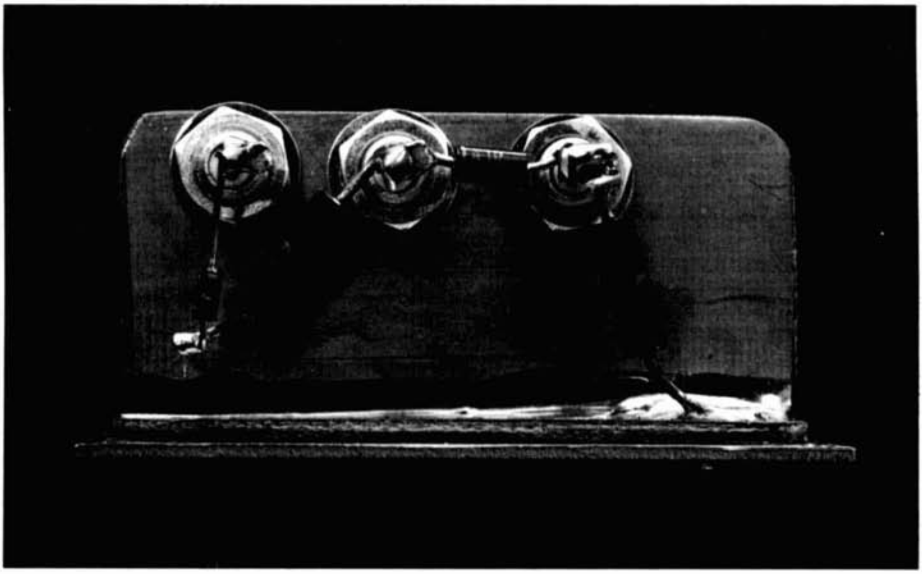
A word about the use of the proposed filter may be in order. After many hours of testing and re-testing various quarter-wavelength filters, I have concluded that a filter should not be tuned while connected to the preamplifier. Best results occur when the filter is adjusted by itself for minimum vswr with a good 50-ohm termination. Then the filter adjustment is locked in place. No further adjustments should be attempted if best results are to be achieved. Just connect the tuned filter to the preamplifier and accept its performance.

If very sensitive test equipment is available, the overall stability of the preamplifier may be tested. The reverse loss (inverting the input and output connections) should be at least 8 to 10 dB greater than the forward gain. The greater this margin, the less chance that the preamplifier is only conditionally stable. Many uhf preamplifiers I have tested only showed 2 to 4 dB difference, a clue to their instability.

performance

The ultra low-noise preamplifier really holds up to its title. The noise figure, when measured with a low-noise converter (2 dB maximum noise figure), is typically 1.2 dB. Some of the FTM4575s have even been below 1.0 dB and few have ever gone above 1.25 dB. The collector current can be easily adjusted by varying the supply voltage ±1 volt. The lowest noise figure usually occurs at 2 mA I_C. With the circuit shown in **fig. 4**, this will measure 3 mA to the preamp (subtract 1 mA, the keep-alive current of the zener diode — see **appendix 2**).

A typical plot of noise figure and gain versus collector current is shown in



Rear view of preamplifier showing locations of R1, R3, CR2 and CR3. Components can be identified from fig. 7 on next page.

fig. 1. However, at 2 mA I_C, the gain will be 1 to 1.5 dB lower and the intermodulation performance will drop by 6 to 8 dB. Therefore, 3 to 3.5 mA I_C is recommended and is set by the values in **fig. 4**. It is interesting to note that the noise figure is optimum from 1.0 to 5.0 mA I_C and therefore no re-tuning is really necessary as only slight improvement is possible at higher collector currents.

If a variable power supply is available, the operating point can be smoothly and easily varied up to 10 mA I_C for improved gain and intermodulation performance. The noise figure will typically only be degraded up to 1 dB under these conditions; if only a fixed supply is available, R3 (see **fig. 4**) can be changed to 390-ohms and an external 1000-ohm potentiometer (wired as a rheostat) can be used to vary I_C. In this case a milliammeter in series with the preamp power supply input is recommended. At extremely cold temperatures the noise figure decreases while the gain increases. Hence, instabilities can occur; they are easily rectified if I_C is varied accordingly.

noise-figure measurements

One last point may be in order concerning noise-figure measurements. Below 500 MHz there are considerable discrepancies when using automatic noise-figure measuring gear and units using the 5722 noise tube. Above 30 MHz these devices tend to generate additional excess noise which tends to make noise figures *look better than they really are*.

For instance, at 30 MHz the output of a typical automatic noise figure generator is 5.2 dB excess noise while at 432 MHz the excess noise can climb to 6.4 dB. If this is not accounted for the preamp may show a 1.2 dB better noise figure than the true value. This discrepancy is well known by the manufacturers and typical values are available. However, manufacturers are reluctant to compensate the older models since it would invalidate all test data and units in the field.

On the Hewlett-Packard 343A this effect can be easily compensated for by lowering the diode current from 3.31 to 2.5 mA at 432 MHz. Errors on the Hewlett-Packard 349A gas tube are less, typically only 0.4 dB. Newer units such as the AIL-75 should not have this problem. The so-called "hot-cold" method of testing is the most accurate system but is tedious and requires liquid nitrogen.

The noise figures quoted in this article have been tested by the hot-cold test method and with automatic test gear that was compensated. Therefore, the results are true noise figures, not ad-

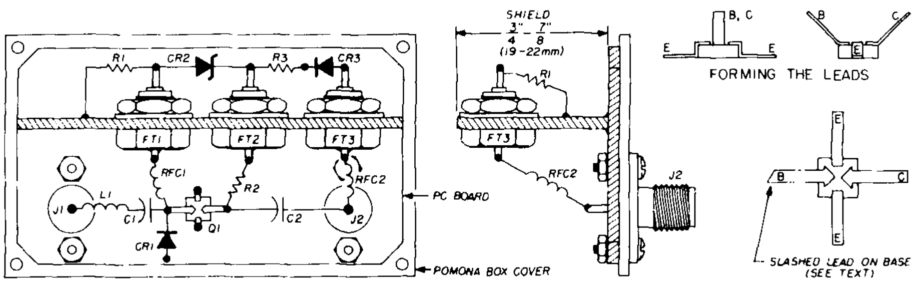
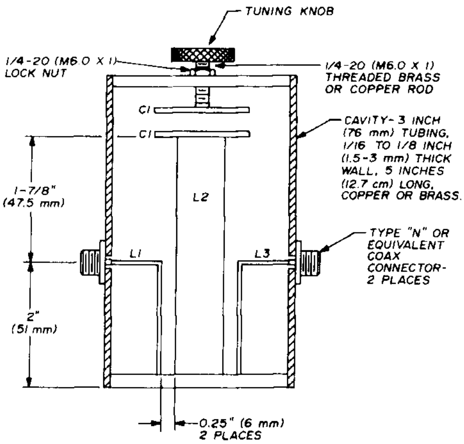


fig. 7. The ultra low noise 432-MHz preamplifier is built on a small section of double-clad printed-circuit board which is attached to the cover of the cast aluminum box.

vertising propaganda. Results have been widely correlated at the National Bureau of Standards, Boulder, Colorado; CSIRO (Commonwealth Scientific and Industrial Research Organization), Sydney, Australia, and elsewhere. In most



C1 1.5-2.0 inch (38-51mm) diameter brass discs soldered to tuning shaft and L2

L1,L3 number-12 copper wire spaced 0.25 inch (6.5mm) from L2

L2 0.75-0.875 inch (19-22mm) OD copper or brass tubing

fig. 8. Typical quarter-wavelength cavity filter for use on 432 MHz. Loss of this design is less than 0.2 dB and 3-dB bandwidth is 15 MHz (typical). Sweat solder the lower ends of L1, L2 and L3 to the base plate. Adjust for minimum vswr with 50-ohm termination and lock tuning control. Cavity may be silver plated for long-term, low-loss performance.

cases this preamplifier exhibited 1.0 to 2.0 dB lower noise figures than the once revered low-noise standards such as the TIXM05, AF239, etcetera.

other variations

As pointed out earlier, this preamplifier works well at other frequencies although performance deteriorates above 500 MHz. The circuit was not optimized for other frequencies. However, even as is, the noise figure will be less than 2 dB at 144 and 220 MHz. Some slight adjustments will easily optimize operation at any frequency from 50 to 1000 MHz.

Other transistors will probably work well in this circuit "as is." However, gain may be lower, the stability poorer, and the noise figure higher. Therefore, some adjustments or changes may be necessary, but these changes have already been discussed and should not be a problem.

summary

This preamplifier should bring you right up to the state of the art in noise figure. It is simple to build and operate with no adjustments necessary. Don't forget the input filter, especially if you operate in a strong rf environment. Remember that this problem may be worse when the preamp is antenna mounted since the input line losses are usually lower.

It is hoped that this article will inspire more vhf/uhf building and operating activity. Antennas and transmitters are presently approaching the optimum. Now it is time to update our receivers to go along with this trend.

My special thanks go to Fairchild Microwave for the use of the test equipment and devices necessary to design this preamplifier. Special thanks go to Will Alexander, WA6RDZ, for all his helpful suggestions. Last but not least, let me thank my wife for typing this manuscript. She says, "It's the most boring thing I've ever typed."

references

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2. J. Kabell and V.H. Grinich, "Zener Diode Circuits for Stable Transistor Biasing," Fairchild Semiconductor Technical Article TP-8, 1961 (now out of print).
3. "Speedy-A Computer Aided Design for RF and Microwave Circuits," Fairchild Semiconductor, Mountain View, California, available on GE time share.

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appendix 1

noise figure

The affect of gain on overall system noise figure can be calculated using the formula:

$$NF_T = NF_1 + \frac{NF_2 - 1}{G_1} + \frac{NF_3 - 1}{G_1 G_2} \qquad (1)$$

where: NF_T = overall system noise factor

NF_1 = noise factor of the first stage

NF_2 = noise factor of the second stage

NF_3 = *noise factor of the third stage*

G_1 = power gain of first stage

G_2 = power gain of second stage

Note that all numbers must be in power gain form since the use of dB will result in large errors, especially when low noise figures are used. Noise factor can be converted to noise figure by applying the formula:

$$\text{noise figure} = 10 \log_{10} (\text{noise factor}) \qquad (2)$$

Conversely, noise figure (dB), can be converted to noise factor by

$$\text{noise factor} = 10 \text{ antilog}_{10} (\text{noise figure}) \qquad (3)$$

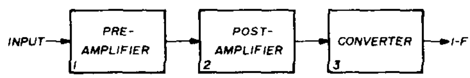
Refer to the illustration below for a typical example. First convert the noise figures (dB) to power factors using **eq. 3**. Then calculate the total noise factor using **eq. 1**

$$NF_T = 1.59 + \frac{4-1}{10} + \frac{10-1}{10 \cdot 16}$$

$$= 1.59 + 0.3 + 0.056 = 1.946$$

$$\text{noise figure} = 10 \log_{10} (1.946)$$

$$= 10(0.29) = 2.9 \text{ dB}$$



dB	NOISE FIGURE, 2 dB GAIN = 10 dB	NOISE FIGURE, 6 dB GAIN = 12 dB	NOISE FIGURE, 10 dB GAIN = 20 dB
EQUIV POWER FORM	NOISE FACTOR, 1.59 GAIN = 10	NOISE FACTOR, 4.0 GAIN = 16	NOISE FACTOR, 10.0 GAIN = 100

Note that the overall system noise figure is 0.9 dB higher than that of the preamplifier alone. Raising the preamplifier gain to 13 dB or dropping the noise figure of the second stage to 4 dB would drop the system noise figure to approximately 2.45 dB – a worthwhile improvement. It quickly becomes apparent that another post amplifier with a lower noise figure may be necessary if you are to approach the low noise figure of the preamplifier. Why pay the price of a low-noise transistor and then lose part of its capability due to a high second-stage noise figure?

appendix 2

zener diode biasing

Refer to **fig. 5**. CR2 is a zener diode and determines the collector-to-base voltage, V_{CB}, of the transistor Q1. The base-to-emitter voltage, V_{BE}, of most low-noise transistors is 0.7 to 0.8 volt and relatively constant. Therefore, the collector-to-emitter voltage, V_{CE}, of Q1 is a fixed voltage which is the sum of the V_{BE} and the voltage of CR2. The current through R3 is given by the equation

$$I = \frac{V_S - V_{CE}}{R3}$$

The current through R3 divides between Q1 and CR2. Ignoring R1, the only current flowing through CR2 is the base current of Q1. Therefore, most of the current flows through the collector of Q1 as I_C. If the dc current gain of Q1 is low, the current through CR2 will increase accordingly. However, if the dc current gain of Q1 is high (as it usually is), the current through CR2 is low and the regulation as a zener is poor. Therefore R1, a 1000-ohm resistor, has been added to the circuit to force at least 0.7 mA through CR2. Since there is usually some base current, a value of 1.0 mA can be assumed for calculations.

As an example, assume you want to operate from a 12-volt power supply with a V_{CE} of 7.0 volts and an I_C of 3.0 mA

$$R3 = \frac{V_S - V_{CE}}{I_C + I_{(CR2)}} = \frac{12 - 7}{0.003 + 0.001} = 1250 \text{ ohms}$$

A 6.2 volt zener would be an appropriate choice for CR2. The collector current can be readily varied by changing either R3 or the supply voltage as indicated in the text. In the circuit of **fig. 4** an additional diode was added in series with the supply voltage for reverse voltage protection. This voltage drop must be subtracted from the power-supply voltage when calculating the value of resistor R3.

solid-state S-meters

These simple solid-state S-meter circuits feature printed circuits that attach directly to the meter terminals

M.A. Chapman, K6SDX, 428 3rd Street, Encinitas, California 92024

It's a pleasure to tune in a nice strong S9 +20 dB signal, but it's even nicer if you have an S-meter on your homebrew receiver with which to read signal strengths. The unfortunate thing is that very few S-meter circuits are available, and most of those that are available are carry-overs from the vacuum-tube days. Several popular circuits using either a single device or an IC have the further disadvantage that they are at full scale with no input signal and decrease with increasing signal strength, just opposite to what you would like to see on the meter face.

The most straightforward approach to signal-strength indication is by voltage amplification of the detected audio. Most detected audio signals are in the 10 to 50 mV range, and pushing this up to drive a 5-mA meter movement takes a voltage gain of about 100, plus the added current gain. Neither of these tasks are easy with a single active device.

Commercially available meters with S-unit calibration seem to be limited to two movements, 0 to 1 mA and 0 to 5 mA types. Many modestly priced and military surplus meters also have these same basic movements. In addition, there are a number of specialty meters with removable scales that use a basic 0 to 1 mA movement, and these can be readily adapted for amateur applications.

Fig. 1 and **2** illustrate two types of S-meter PC boards which mount directly to the rear of a meter using the

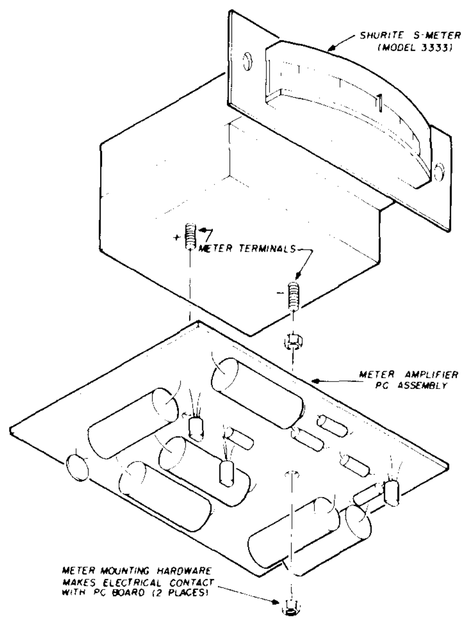


fig. 1. Construction of the 5-mA S-meter circuit shown in fig. 4. Printed-circuit layout is shown in fig. 7.

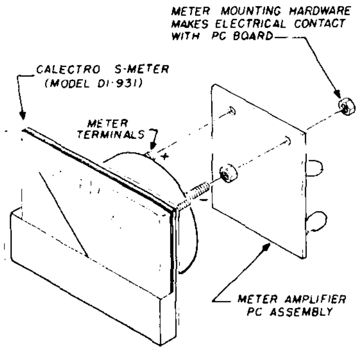


fig. 2. S-meter assembly designed for Calectro D1-931 1-mA meter. Circuit is shown in fig. 3, printed-circuit layout in fig. 5.

meter's plus and minus terminals. This allows free access for panel mounting, separates the meter-amplifier circuits from the rest of the receiver, and provides for easy add-on or modification at a later date.

circuit operation

Fig. 3 shows a schematic for a meter amplifier designed for a 0 to 1 mA S-meter. The fet input provides a high impedance to the detected audio and minimizes loading and distortion problems. The second stage, Q2, is a common-emitter voltage amplifier with a simple positive pulse rectifier for the meter. The 35-μF meter shunt capacitor, C1, filters the rectified audio signal.

Fig. 4 is an S-meter amplifier for a typical 0 to 5 mA meter movement. Similar to the 0 to 1 mA design, the second-stage voltage amplifier, Q2, is followed by an impedance-matching stage, Q3, a simple emitter follower. Performance specifications for both circuits are given in **table 1**.

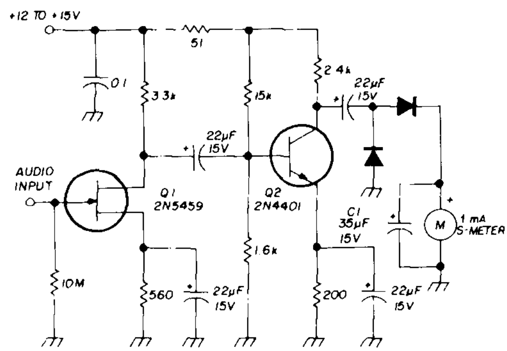


fig. 3. S-meter amplifier designed for a 1-mA meter movement consists of two-stage voltage amplifier and meter rectifier. Printed circuit for this circuit is shown in fig. 5.

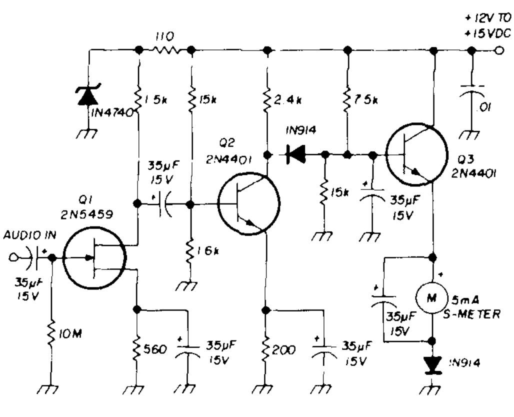


fig. 4. S-meter circuit designed for 5-mA meter movement uses two-stage voltage amplifier with an emitter-follower output. Printed-circuit layout for this circuit is shown in fig. 7.

construction

Fig. 5 and **7** show the PC board layouts and component installation diagrams.* Resistors can be 1/8- or 1/4-watt units although 1/2-watt components can be bent slightly or installed

table 1. Performance specifications of the S-meter circuits shown in figs. 3 and 4.

Audio signal input (S-9)	25-30 mV p-p
Audio signal input (full scale)	50-60 mV p-p
Frequency response	500 Hz to 10 kHz
Input Impedance	greater than 1 meg
Power supply	12 to 15 Vdc

*Undrilled printed-circuit boards are available from the author for $1.00 postpaid.

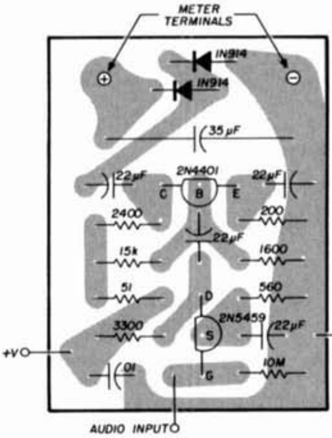


fig. 5. Printed-circuit layout for the 1-mA S-meter circuit. Full-size printed circuit is shown in fig. 6.

vertically on the board to fit. The values for the source and emitter bypass capacitors is arbitrary, and almost any tantalum or electrolytic above 5 or 10 µF will work satisfactorily. An inexpensive dipped tantalum is recommended. The same general capacitance discussion applies to the 5-mA board, but more room is available on this board for the installation of axial-lead components.

An infinite number of transistor substitutions are possible in these two circuits. Almost any audio n-channel, depletion-type fet should work at Q1 by adjustment of the 560-ohm source resistor for maximum voltage gain at the base of Q2. A general-purpose audio npn transistor can be substituted for Q2 and Q3 by adjusting the 15k bias resistor of Q2, and the 7.5k bias resistor of Q3, respectively. In both cases the resistors should be selected for maximum voltage gain to the succeeding

fig. 6. Printed circuit for the 1-mA S-meter. Component layout is shown in fig. 5.

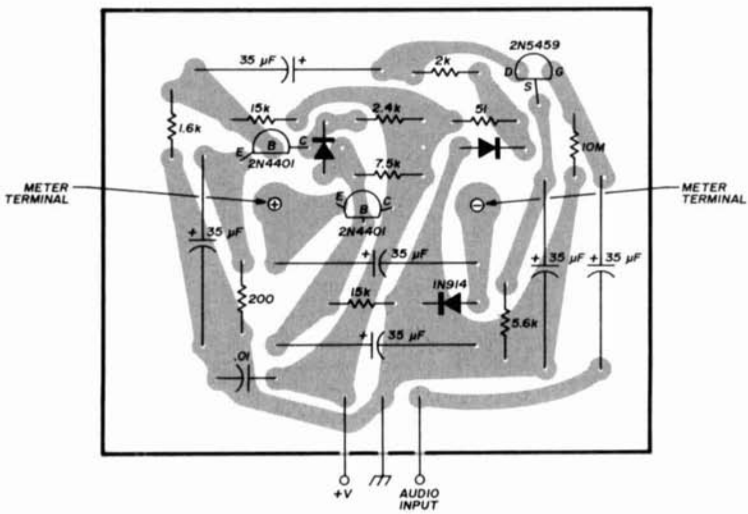


fig. 7. Printed-circuit layout for the 5-mA S-meter circuit. Full-size printed circuit is shown in fig. 8.

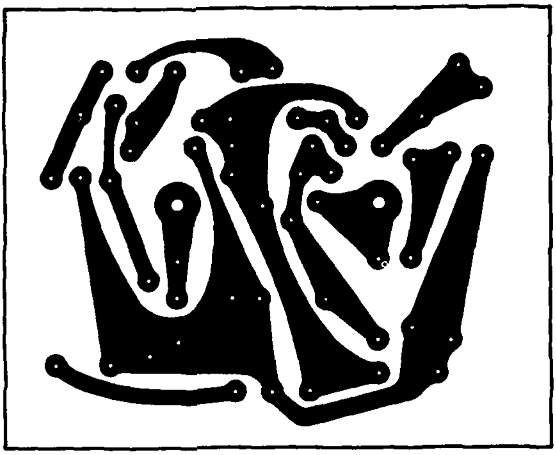


fig. 8. Printed circuit for the 5-mA S-meter. Component layout is shown in fig. 7.

stage or in the case of Q3, selected for maximum meter movement. When selecting bias resistors, it is suggested that a 20- to 50-mV 1000-Hz audio signal be applied to the input of Q1, and that a high-impedance scope or vtvm be used to monitor signal gain.

application notes

Fig. 9 shows a typical application for the S-meter assemblies in a receiver. Since the detected audio level will vary with each receiver, it is necessary to install a sensitivity adjustment. Although this schematic shows a potentiometer, a simple two-resistor voltage divider is adequate. The sensitivity adjustment should normally be set for a meter indication of S9 (approximately half scale) with a modulated 50 μV signal applied to the receiver's antenna terminal. The sensitivity control should be a 50k to 100k unit to minimize loading effects on previous stages.

Since many 0 to 1 mA and 0 to 5 mA meters have different screw terminal locations than those shown here, you may want to use Vector board construction, following the general parts and connection data shown in **fig. 5** and **7**. An alternative is to locate the PC board externally and use jumper wires to the meter.

If meter motion bothers you, the needle can be damped (or left to free swing) by increasing (or decreasing) the value of the 35-μF meter shunt capacitor.

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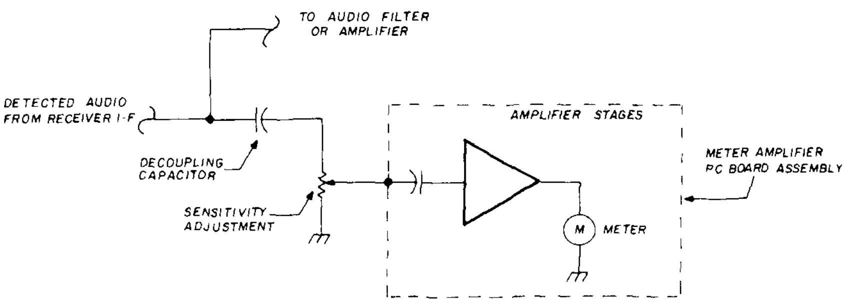
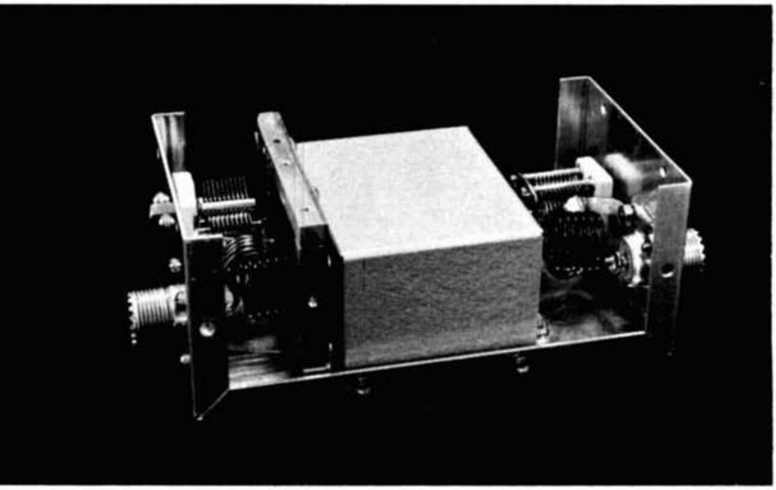


fig. 9. Installing the S-meter amplifier in a typical receiver. Sensitivity pot may be replaced by simple resistive voltage divider, if desired.



high-frequency lowpass filter

A simple, easily duplicated, lowpass filter, with 60-dB attenuation on channel 2 that can be built for under five dollars

Neil Johnson, W2OLU, 74 Pine Tree Lane, Tappan, New York

One of the best ways to motivate a casual reader to build a project is to describe something comparatively simple to construct which has more-or-less universal appeal. When such a project is presented along with a solution to any parts procurement problems, the desired result is often achieved: the reader becomes a builder. The following is offered with such a philosophy in mind.

design

Recently a supply of high-quality ceramic capacitors came to my attention at the extremely low price of six for a dollar – they usually sell for three dollars apiece. These are ideal for a TVI lowpass filter being rated at 67 pF at 7500 Vdc and they are small enough to be non-inductive since they're only 3/4 x 3/4 inch (19mm x 19mm). My first thoughts were to use these in a relatively non-critical lowpass filter circuit of the type shown in **fig. 1A**. This is merely a combination of three pi-section filters, as shown in **fig. 1B**. No tune-up adjustments would be needed, and the circuit is easily reproduced. That dream went down the drain when the resultant filter showed comparatively low attenuation at TV channels 2 and 3. Unfortunately this is where it is needed most. One could re-design, possibly by lowering the cutoff frequency and thus omitting 28-MHz coverage, but only at the cost of larger, more cumbersome, and more expensive components.

Back to the old reliable. If we elect to keep the good features of the simple filter mentioned above, and then add series-tuned circuits at each end of the filter, we find that most of our needs can be satisfied by the design shown in **fig. 2**. Engineers describe this type of lowpass filter as having M-derived terminating half sections at each end, with two *constant-K midsections*. Most of the construction is non-critical, and when the end sections are tuned to channel 2 (55 MHz) or channel 3 (61 MHz) the theoretical attenuation approaches 60 dB, a ratio of one million to one! Assuming that your transmitter is properly shielded and filtered, this should cure any TVI problems except the toughest ones. As an unintended bonus, this should prove to be a very rugged filter, difficult to burn out even when operated on lines with high standing-wave ratios.

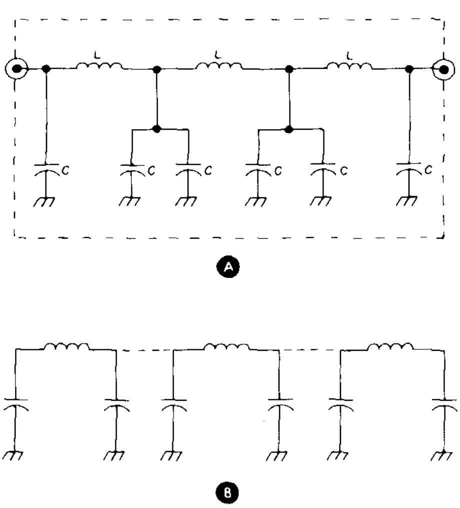


fig. 1. Initial filter design in (A) provided poor attenuation at crucial lower television channel frequencies. Electrical equivalent of the circuit is shown in (B).

chassis

I used an unpainted LMB type 780 "tight-fit" chassis as the basis for this filter. It is made with a great deal of attention, and the close mechanical tolerances employed by the manufacturer should endear this type of chassis to all filter builders. I also tried to simplify the internal shielding problem by using a smaller LMB type 770 "tight-fit" chassis to enclose the center section of the filter. While this is a good design, I felt that even better shielding and harmonic attenuation were called for, at least in the prototype circuit. The additional vertical shield is the result of these considerations.

Personally, I doubt whether such extreme "weatherproofing" is required in all installations. You might simplify your construction initially by omitting the vertical interstage shield, adding it later if needed. In a strong TV signal area I don't believe this shield will be necessary. The ¼-inch (6.5mm) square rods which I attached to the main chassis cover as a precautionary measure are similarly optional.

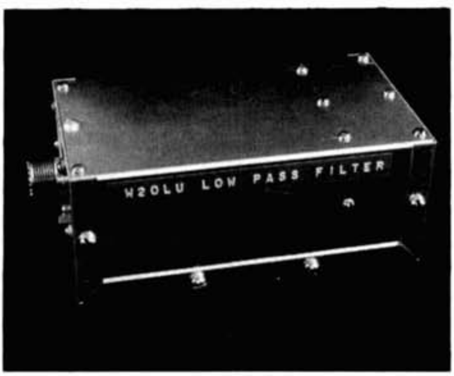
coil winding instructions

All five coils are wound with either number-16 or -14 enameled wire,* using a ½-inch (12.5mm) diameter form as a mandrel. Wind the coils in closewound fashion and leave 1-inch (25mm) pigtails at each end. Bend these at approximately right angles, carefully remove

*Do not attempt to use bus-bar wire or hard drawn copper wire for the coils. These types are prone to spring open to a greater diameter when removed from the ½-inch (13mm) form.

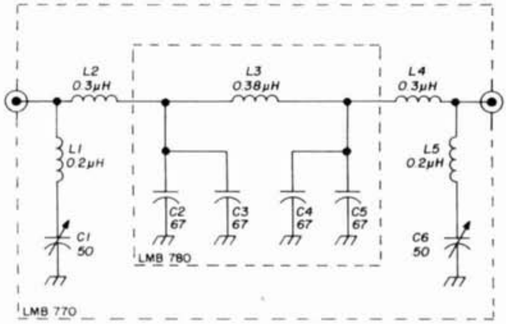
the enamel, and tin the ends. Space the coils uniformly by using a 2-inch (51mm) length of number-14 wire as a gauge, passing it between the turns from one end of the coil to the other. After this is done, make certain that the shape and spacing of the coils is not altered by handling; if this happens, re-space the turns with a piece of number-14 wire as outlined above.

I used number-16 enameled wire for the end-section coils (L1 and L5), since the current carrying capacity of number-16 wire (22 amperes continuous in open air) is more than adequate. I chose number-14 wire for the inductors carrying the throughput (L2, L3 and L4) since I wished to keep losses down. The filter should be capable of handling the output of all but the highest powered amateur rigs, although it was designed to serve the 90% of amateurs who own high-frequency rigs in the 200 to 300 watt input class. All capacitors were checked at 1000 volts ac before installation, and the completed filter was tested at 700 volts ac. A 1-kW input transmitter will have an rf output of 800 watts at most; if this is fed into a well matched 50-ohm coaxial line, the maximum rf voltage will be 200 volts at a line current of 4 amperes.* The filter could probably handle this with no trouble.



W2OLU's lowpass filter is housed in LMB-780 chassis which provides a compact, nearly rf-tight enclosure.

It is not necessary that the mechanical layout be followed, but if you do, success will be easier to come by. One item of note: In the mechanical design of this filter I took a close look at the problem of interstage leakage. When you consider that the coils are only



C1,C6	50 pF APC or MAPC variable
C2,C3 C4,C5	67 pF ±5%, 7500 working volts dc (Centralab type 850S ceramic capacitor, 6 for $1.00 from John Meshna, P.O. Box 62, E. Lynn, Massachusetts 01904)
L1,L5	0.2 μH, 3 turns no. 16 or no. 14 enamelled, ½ inch (13mm) ID, spaced 1/8 inch (3mm) per turn
L2,L4	0.3 μH, 5½ turns no. 14 enamelled, ½ inch (13mm) ID, spaced 1/8 inch (3mm) per turn
L3	0.38 μH, 7 turns no. 14 enamelled, ½ inch (13mm) ID, spaced 1/8 inch (3mm) per turn

fig. 2. Final design: lowpass filter with 42.5-MHz cutoff frequency and theoretical attenuation of TV channels 2 and 3 greater than 60 dB. Filter is enclosed in LMB 780 chassis (5.25x3.0x2.13 inches [134x76x54mm]; components C2, C3, C4, C5 and L3 are enclosed in an LMB 770 box (2.75x2.13x1.63 inches [70x54x41mm]). Construction details are shown in the photographs.

½-inch (13mm) in diameter, the large holes often found in interstage shielding assume noticeable proportions. To keep inductors L2, L3 and L4 from "seeing" each other, I reduced the diameter of the pass-through holes to 3/16 inch

*Standing waves on the line will cause the maximum rf voltage to increase. **Editor**

(5mm). Also, center inductor L3 was offset so that it was mounted as far as possible from the other two parallel mounted coils. Attention to these seemingly small details makes the difference between a first-class filter and one having only "so-so" characteristics. It is all

MHz for channel 3) with a grid-dip oscillator. If you lack this simple instrument, I found that if the filter is constructed closely following the original, the two end capacitors are each about 75% fully meshed and at an angle of 41°. This was measured both with a

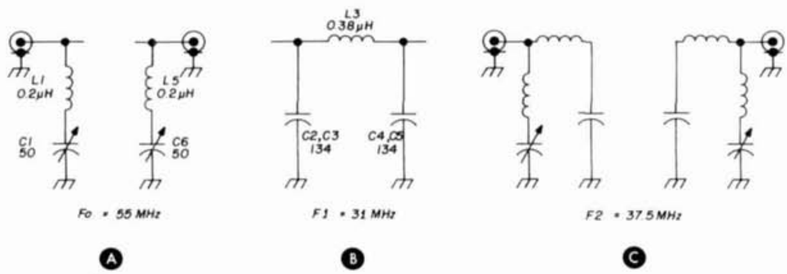
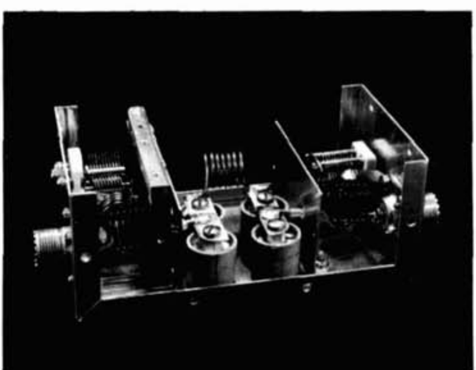


fig. 3. Tuneup data for the lowpass filter. The input and output sections in (A) are first shorted to ground and tuned to 55-MHz (Channel 2 video carrier) or to 61 MHz (Channel 3 video carrier). Center section in (B) should resonate at 31 MHz, and terminating half-sections (C) should resonate at 37.5 MHz. Filter cutoff frequency is 42.5 MHz.

too easy to nullify part of the potential attenuation of such a filter unless you remember that our goal is to cut down on TVI harmonics by a ratio of a million-to-one!

tune up

When the end sections are first installed, short them to ground with a short strap and dip them to 55 MHz (61



Center section of the filter consists of four 850S ceramic capacitors and one inductor, contained in a LMB 770 Minibox.

machinist's protractor and the 25¢ plastic type that can be found in stationery stores. If the filter is built as described, the intermediate sections should come out close to the optimum figures (see **fig. 3**) since the mid-section capacitors are rated at 5% accuracy.

conclusion

Full instructions for dipping and tuning lowpass filters can be found in both the *ARRL Handbook*[1] and the *Radio Handbook*[2]. Follow the drawings closely and the odds are that the TVI beasties will no longer flow out through your coaxial line. Total cost? A pleasant surprise in these days of high inflation. How does five dollars strike you . . . and with spare parts left over!

references

1. *Radio Amateur's Handbook*, 47th edition, ARRL, Newington, Connecticut, 1970, page 585.
2. *The Radio Handbook*, 17th edition, Editors and Engineers, Ltd., New Augusta, Indiana, 1967, page 380.

ham radio

channel scanner

for the Regency HR-212

Construction data for a 12-channel frequency scanner to update this popular two-meter transceiver

Ray Johnson, WAØSJK, Marion, Iowa 52302

If you've been thinking about trading your Regency HR-212 two-meter fm transceiver for one of the scanning models on the market, but find you have more time than money, then this modification may be the solution to your problem. For about $20 you can provide your HR-212 with scanning capability.

Explicit details on parts layout are not included because the circuit was built on a board designed for experimentation and isn't the best possible layout. Although I used wire-wrap for IC interconnections, there's no reason why someone with more time and talent couldn't use printed-circuit techniques. As the photo shows, the mods made to the transceiver front panel don't detract from its appearance.

Since the HR-212 uses diode switching of receive crystals, half of the scanning circuit is already contained in the unit. The circuit described here is essentially an electronic switch which replaces the receive mode rotary switch, S2, on the HR-212.

The scanning circuit operates as follows:

1. The circuit scans 2, 3, 4, 5, 6, 7, 8, 10 or 12 channels, depending on how programmed. These numbers can be changed easily when crystals are added or removed.

2. Scanning will stop and remain stopped on the channel being monitored if:

A. There is an incoming signal on that channel.

B. The LOCK switch is in the LOCK position.

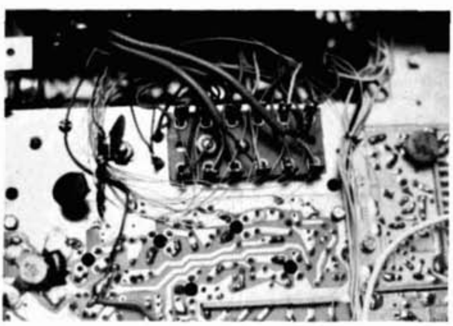
C. Transceiver is in the transmit mode.

D. The SCAN-MANUAL switch is in the MANUAL position.

Scanning will resume three seconds after the locking stimulus has been removed.

3. If scanning has been locked manually, pushing the STEP switch causes a jump to the next channel. If the scanner is stopped on an incoming signal, pushing the STEP switch will cause the scanning operation to resume until another active channel is encountered.

4. The SCAN-MANUAL switch takes the place of the original mode switch, S3, on the HR-212. When placed in the MANUAL mode, the scanning circuit is disabled and receive frequency follows transmit frequency. (Transmit frequency is always determined by the transceive rotary switch.)



Bottom view of Regency HR-212 showing terminal board and voltage-regulator leads protruding through chassis. Small wires go to scanner board switching outputs, others go to LEDs and crystal-switching diodes (S1A).

construction

Receive channel indication is by means of LEDs, one for each channel

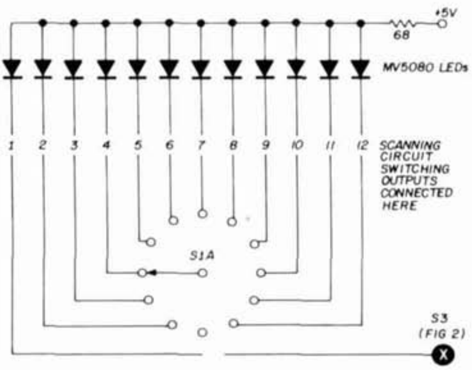
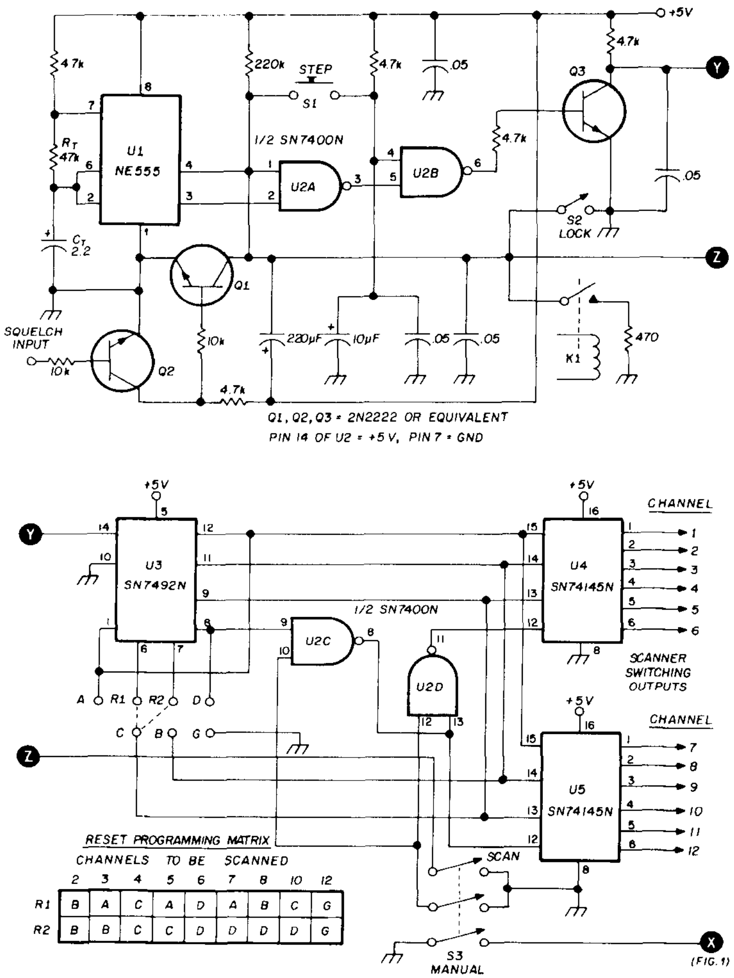


fig. 1. LED board and switching connections. Switch S1A is the transceive 12-position switch on the HR-212. The HR-212 switching diodes are common to this switch (CR501 through CR512).

(**fig. 1**). The LEDs are placed on a 3x2½-inch (76x64mm) copper-clad circuit board, which is then mounted to the front chassis panel (see installation instructions). These LEDs will then protrude through small holes which are drilled in the front panel of the cabinet. I chose to place the indicators on the right side of the channel identification positions. This method still left enough room for identification using standard ¼-inch (6mm) embossing tape.

The scanning circuit (**fig. 2**) is constructed on a 2x4½-inch (51x114mm) copper-clad circuit board. Discrete components are interconnected through the copper of the circuit board wherever possible. Wire-wrap sockets are used for the integrated circuits, and connections are made between them and to the discrete components using wire-wrap terminals which are soldered to the board. Discrete component values can vary to some extent from values given with the exception of Resistor R_T and capacitor C_T. Therefore, don't be afraid capacitors (**fig. 3**). This IC comes packaged in a TO-3 transistor case and can be mounted directly to the chassis below the scanner board. Don't neglect to use the bypass capacitors as shown with the voltage regulator as it is impor-



	2	3	4	5	6	7	8	10	12
R1	B	A	C	A	D	A	B	C	G
R2	B	B	C	C	D	D	D	D	G

fig. 2. Scanner board schematic. Logic can be changed via the programming matrix to scan any desired number of channels.

to use your junkbox. Almost any npn silicon transistor can be used for Q1, Q2 and Q3.

The 5-volt power supply necessary for the ICs and LEDs consists of an LM335 voltage-regulator IC and several tant to keep rf and transients out of the 5-volt supply.

testing

When the scanner board has been completed, test it with an oscilloscope or voltmeter before mounting it in the HR-212. Before applying 5 volts, connect the squelch input to a 5-volt point in the circuit and ground pins 6 and 7 of the SN7492 IC (U3). When voltage is applied, a square wave of approximately 6 Hz should be detected on the collector of Q3 (point Y). If no square wave is present, then look for it on pin 3 of the NE555 timer IC (U1). If nothing is there, then check the voltage on pin 4 of U1 and U2; both should read more than 2 volts dc. If the oscillator is working properly, then check the squelch locking circuit by grounding the squelch input. Oscillation should cease abruptly. When 5 volts is reapplied to the squelch input, oscillation should resume in about three seconds.

The scanner board switching outputs are checked as follows: place a 10k resistor between 5 volts and pin 1 of U4 (SN74145N). If the oscillator is running, the voltage on this pin should drop to zero momentarily once every two seconds. Perform this same test for pins 2 through 6 of U4 and 1 through 6 of U5. Now ground pins 10 and 12 of U2 (SN7400N). All switching outputs should remain constantly at 5 volts. If the scanning circuit has passed all the preceding tests, then wash up and prepare for surgery (if you're not shaking too badly).

installation

First remove the dial light from the receive dial (right) side of the HR-212. Then cut the wires off of the receive channel rotary switch (S2 of HR-212) close to the switch. Remove the 12-position rotary switch and replace it with a 3-pole, 2-position rotary switch. Mount the LM335 voltage-regulator IC on top of the chassis (centered in front of the transmitter circuit board). Mount a 12-terminal board or block on the underside of the chassis below the voltage regulator. Connect the wires remaining from the removal of S2 to this terminal board in a sequential manner.

LED board. Position the board in front of the chassis, making sure it clears the transceive dial on the left. Mark and drill holes for the manual-scan switch shaft and the momentary contact step switch (this switch is mounted on the LED board). The step switch will protrude through the hole vacated by the receive dial window on the front cabinet panel. Remove the front panel from the cabinet and drill twelve 3/32-inch (2.5mm) holes for the LEDs. Then line up the LED board and front panel using the hole drilled for the manual-scan switch shaft as a guide.

Clamp the panel and board together and drill the LED board using the front panel as a template. These holes should then be enlarged to 1/8 inch (3mm). Etch a suitable pattern on the board to which the LEDs can be soldered, and make a provision for the 68-ohm current-limiting resistor. When the LEDs are mounted, check to make sure they all work, then secure with epoxy. This is very important, because the MV-5080 LEDs have very delicate leads that will break off if the LEDs have any freedom of movement. Finally, attach thirteen 8-inch (20cm) leads to the board (one for each LED and one for the 5-volt common bus).

Mount the momentary contact switch on the LED board, then carefully position the board on the front chassis panel and mount it on ¼-inch (6mm) spacers. The spacers should be secured to the chassis first, then the LED board should be positioned loosely over both the spacers and nuts. Dress the wires through the front chassis panel and connect them to the proper terminals on the terminal board beneath the chassis. Connect the 5-volt common lead directly to the 5-volt side of the voltage regulator.

Scanner board. Mount four 1-inch (25.5mm) spacers to the chassis and secure them with nuts. Position the scanner board far enough away from the front chassis panel so that wires can be routed between, then mark and drill mounting holes on the circuit board. Mount the board loosely on the spacers.

Connect twelve wires to the switching outputs using the wire-wrap tool, then connect the other ends to the appropriate terminals below the chassis. The rocker switch on the HR-212 is now used for the locking switch, S2. It should be open in the UNLOCKED position. Two unused, normally open contacts on the HR-212 transmit-receive relay are used for K1. The 470-ohm resistor in series with this relay is optional. Its function is to shorten the delay time of the scanner. This may be desirable if most of your activity is via repeaters.

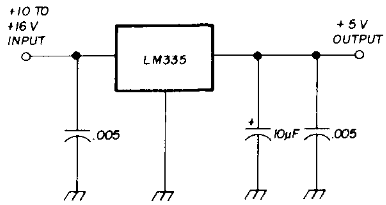


fig. 3. Power supply for the scanner modification uses a LM-335 voltage-regulator IC. Bypass capacitors are important.

The squelch input is connected to the HR-212 receiver. Locate R5, a 33k resistor connected directly to the transmit-receive relay; replace this resistor with a 27k resistor. The squelch input line should be connected to the side of this resistor that is *not* common to the relay.

Follow the programming matrix for setting the number of channels you intend to scan. The dashed lines on the schematic show how the scanner would be programmed for four channels. You may wish to employ a switch or switches to facilitate easy programming. Connect the SCAN-MANUAL switch to the circuit board and note that the rotating contact of the TRANSCEIVE rotary switch should also be connected to the SCAN-MANUAL switch at point X. All that remains to be connected now is the power supply. Try the scanner out for awhile before you fasten the board down. The scanning rate can be increased by making C_T or R_T smaller (preferably C_T only).

conclusion

Parts layout for the scanner circuit is not critical. There was enough room on the board for the scanner as well as a tone-burst oscillator, which was designed around a Signetics NE566 function-generator IC. You may wish to lay out the entire project on a printed-circuit board rather than use the wire-wrap method.

The greatest problem encountered with this scanning unit initially was that it tended to go wild during transmit operation due to rf and transients getting into the TTL ICs. This should not be a problem if all bypassing capacitors shown are used. Additional 0.05-μF capacitors can be installed at the V_{CC} input of each IC if this problem persists.

If you don't like the idea of drilling holes in your HR-212 cabinet, you might consider building the scanner as a remote unit. This will require a 15-conductor cable and connectors. The output of the SN7492 counter could be used with a BCD-to-seven-segment decoder to drive a seven-segment display as a means of channel identification.

If you live in an area with a lot of two-meter activity you'll probably find it necessary to improve the selectivity of your HR-212.[1] If you don't, you may find the scanner locked on 146.88 MHz while the received station is transmitting on 146.94 MHz.

reference

1. Paul J. Dobosz, WA8TMP, "Narrowband Modifications for the Regency HR-2 Series of VHF-FM Transceivers," *ham radio*, December, 1973, page 44.

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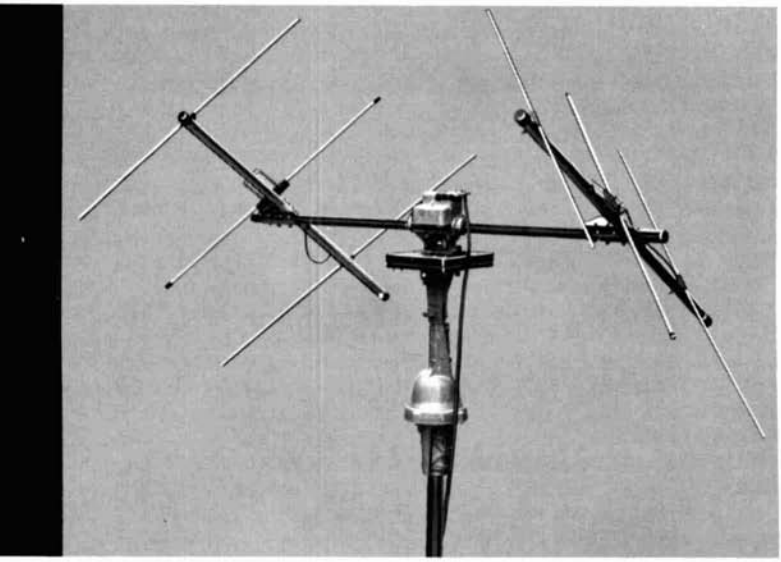


low-cost az-el antenna mount for satellite communications

This simple, easy-to-build azimuth-elevation mount will provide added range for satellite contacts

Stuart D. Cowan, W2LX, Box 596, Rye, New York 10580

This article describes a simple, easy-to-build az-el (azimuth and elevation) mount for medium-sized vhf beams, and suggests that experimenting with the angle of elevation of beam antennas and the type of polarization, using the various vhf propagation modes, may yield useful scientific information.

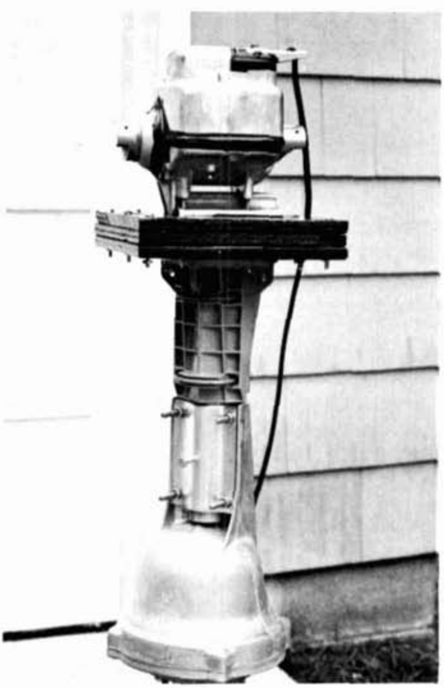
In my az-el antenna mount the azimuth rotor is a TR-44, although a smaller, less expensive unit would work as well with small beams. (Oscar 6 expert K2BZT uses two Alliance U-100 rotors in his az-el mount which handles a 10-element circularly polarized Yagi.) The TR-44 azimuth rotor is mated to the bottom plate of a plywood *sandwich* by an 11-inch (28cm) stub mast and the bottom mast support which comes with CDR rotors. The stub mast can be as long as five or six feet (1.5 to 2 meters) to get the beam antennas higher, but much more than that would be pushing your luck in ice and wind storms.

plywood sandwich

The plywood sandwich consists of two pieces of half-inch (13mm) plywood 8x9½ inches (20x24cm) and four spacers of the same material which keep the top and bottom plates one-half inch (13mm) apart so that the mounting hardware does not touch. Construction details for the plywood sandwich are shown in **fig. 2** and **3**.

A unique feature of the sandwich is that the elevation rotor mounts directly over the azimuth rotor which results in balanced downward thrust. Unbalanced weight creates a bending moment which strains both mast and rotor.

fig. 1. Alliance U-100 elevation rotor mounted directly over CDR TR-44 azimuth rotor by means of plywood sandwich and 11-inch (28-cm) stub mast.



Before assembly, the two plywood plates and four spacers should be sanded and given at least two coats of high quality, outside house paint. After the sandwich is bolted together, the two seams are sealed with vinyl tape to keep water out, and the unit is given a final coat of paint. If this sounds too fussy, it is only because I have seen water pour out of waterproof baluns, trickle down the inside of new coaxial cable, split and destroy plywood, and fill a sealed quarter-wave transformer made of hollow tubing. No one will ever know how many weak signals are due to watered-down power!

elevation rotor

The U-100 elevation rotor is attached to the top of the plywood sandwich *using the mast hardware supplied with* the unit. Use flat washers and lock washers throughout. Tape the seams of *the U-100 to keep water out.* The bolts holding together the two halves of the U-100 loosen with time; tighten them *every six months.*

The U-100 rotor permits the boom holding the vhf antennas to pass entirely through the rotor unit, as the photographs show. Blonder-Tongue Prism-Matic rotors offer the same advantage. This is a must to achieve proper weight balance. If a single crossed Yagi is mounted on one side of the elevation rotor, a counterweight should be mounted on the opposite side.

The cross boom is a 5-foot (1.5-meter) wooden pole from a beach umbrella in order not to detune the Yagis, which should be mounted as closely together as possible. A metal boom could be used, but I prefer a strong, well painted wood boom for proper decoupling.

The two 3-element Yagis are mounted at 90° to each other, and 45° to the boom. One beam could be mounted vertically and the other horizontally, but that posed a problem in this case because of the beam hairpins and baluns. The stub mast must be long enough to permit the beams to clear the supporting structure when the beam is rotated at full 90° elevation.

elevation control

A word of caution: before installing your masterpiece on top of a tall tower or high roof, conduct a dry run on the ground where you can easily, "correct any malfunction," as they say in the electronics industry. (The first time I elevated my antennas they pointed down into the driveway.)

Calibrating the elevation control is simple. I use east for the horizontal position and north for 90° elevation (straight up). A paper elevation calibration chart is pasted to the control unit between E and N.

use with satellites

While you do not need a beam, or an az-el mount, to work successfully through a satellite, using a good beam on such a mount gives superior results

fig. 2. Details of sandwich made of ½-inch (13mm) plywood, well painted against weather. Bottom plate bolts to mast support for TR-44 or Ham-M rotor. Top plate bolts to U-100 rotor. Bolts fasten plates together, separated by four plywood spacers. Dimensions are shown in fig. 3.

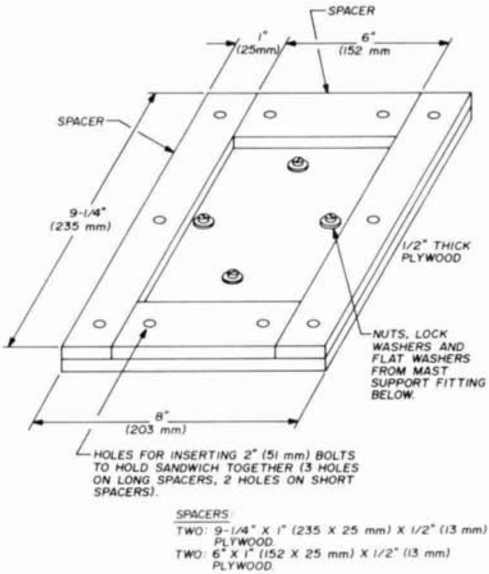


fig. 3. Construction details for the bottom plate of the plywood sandwich. Top plate is similar (see fig. 2).

with less power. And the tests you can make are very educational. The Oscar satellites give you an opportunity to do something *which amateurs have never before been able to do* – listen on the downlink to your own signal coming back to you from a distant point (outer space) so that you can instantly hear the results of changes in power, types of antennas, and beam headings and elevation angles. There's no guesswork, no baloney, no inflated reports!

With a satellite, those adventuresome souls with a high-gain beam on an az-el mount are the first stations to access the bird on its pass, have the best signals (if they keep the beam heading in the right direction, at the right elevation), and work through the satellite up to the last possible moment before it drops over the horizon. On the other hand, an az-el mount keeps you a lot busier on a satellite pass than a fixed antenna so if you are the nervous type, you probably would be better off to stick to a ground plane. Another possibility is the automatic az-el control system described in the January issue of *ham radio*.[1]

vhf propagation

There are numerous types of vhf propagation to explore and much to learn about over-the-horizon vhf/uhf paths, most of which exhibit very unpredictable behavior. Here is ideal territory for the purposeful amateur seeking a chance to contribute to scientific knowledge.

For example, does the angle of elevation of an efficient multielement beam with a relatively narrow main lobe affect vhf/uhf propagation which results from ducting, sporadic-E, temperature inversion, obstacle gain, aurora reflection, tropospheric scatter, ionospheric scatter, etcetera? If it does affect propagation, then in what way?

It is already known that the angle of elevation is important in satellite and moon reflection communications. Moonbounce expert W6PO reports that once an antenna is high enough to be free of ground effect, elevation control is a key factor in meteor trail reflection, making possible short-range communications (under 500 miles), such as between California and Nevada. Antennas are tilted upward and aimed at a meteor shower over northern Oregon so that the angle of reflection equals the angle of incidence on the reflection path. *Presto* – meteor reflection contacts over short distances!

polarization

Besides experimenting with the angle of elevation, worthwhile tests can be conducted comparing horizontal, vertical and circular polarization (right- and left-hand). W6PO suggests that tilting an array *sideways* – halfway between horizontal and vertical polarization – to achieve "lopsided polarization" might lead to interesting results.

fig. 4. Assembly, supported by four braces, mounted on 2x4-foot (60x120cm) plywood frame for fastening to flat area. TR-44 rotor can be mounted on regular tower. Length of mast from TR-44 to U-100 should not exceed 5 to 6 feet (1.5-2 meters).

Circular polarization may be produced with a helical beam, or with two Yagis, one of which is fed 90° out of phase with the other. The Yagis may be on the same boom, or separate as shown here. With Yagis, the transmission line to one beam is an electrical quarter-wavelength longer than the line feeding the other beam, thus imparting a minute delay in the power fed to the second

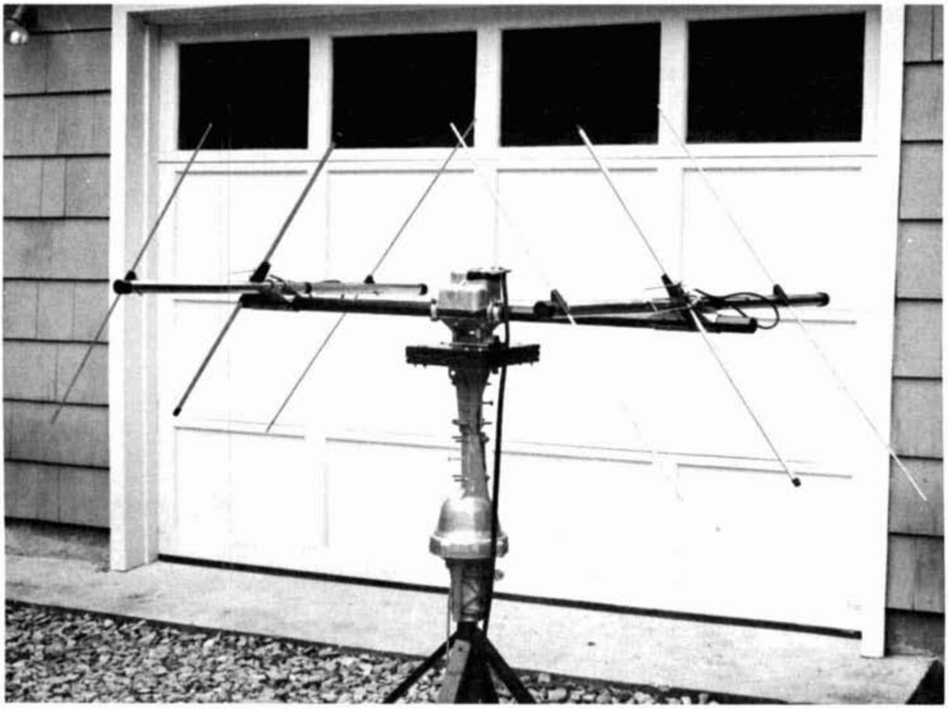


fig. 5. Az-el mount assembled using two 3-element 144 MHz Yagis at 90° to each other for circular polarization. Cross boom extends through U-100 rotor. Feed line and phasing harness not shown.

beam. Data on circular polarization may be found in references 2 and 3.

The results of these tests can be recorded by a reliable observer at the other end of the path, preferably using a tape recorder, or better, by having that amateur patch your signal into the telephone line so that you can actually hear the effects of the changes you make.

summary

Vhf and uhf territory, 50 MHz and higher, is one of the few remaining frontiers where pioneering amateurs still have an opportunity to contribute scientific discoveries in the honored tradition of the amateur service (the discoveries have been a bit sparse of late).

Except for satellite and moonbounce communications, little is known about the effects of changes in angle of elevation of antennas, and their polarization, on the propagation and reception of vhf and uhf signals. Who can tell what awaits the determined amateur with a pioneering spirit?

Thanks are due K2BZT, W6PO and W6SAI for data in this article, and to WA2ECC for the photographs.

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More Details? CHECK–OFF Page 94

programmable calculators

for solving engineering problems

An example of the versatility of these machines plus some expert advice on their use

Raymond P. Aylor, Jr., W3DVO, 4708 Argyle Avenue, Garrett Park, Maryland 20766

During the last few years the use of small electronic calculators has become increasingly popular in broadcast and communications engineering. The small units available, even the $19.95 housewives' grocery-store special, offer a speed of operation and portability far above that of the slide rule. Almost overnight the field of mechanical calculators has been wiped out by progress.

In keeping with progress, a new breed of calculators of the mini-computer type has appeared on the market and several machines of reliable manufacture are now available. They are within reach of the average budget and will prove themselves in the first engineering problem calling for a repetition of calculations to be made in some orderly sequence. These machines are known as programmable calculators: they can accept one or more programs and can process them from a series of memory registers. Numbers may be recalled, changed, or restored at will in these registers.

programmable computers

The word "programmable" is apt to conjure up some scary ideas in the mind of the casual reader. Let's see what the word means. We may start out and store in the memory registers those quantities that are known or which we'll want to process, doing all this before we load the program into the machine. If desired, a sample calculation may be made at this point to acquaint ourselves with the routine, but this is not really necessary. Better that we go into LOAD, then proceed as if we were making an ordinary calculation, manipulating the keys to work toward an answer. Then we go back into the RUN mode. The program is now stored and we may insert new values into the memory registers and give the machine the go-ahead to process the new data.

The beauty of such an operation is that it doesn't have to be entered in a precise machine language such as BASIC, FORTRAN IV, or COBOL. In these languages, the big sophisticated machines must be commanded in an exact routine, using precise statements, and using exact names for what is to be done. In the operation described here, the user simply goes through a series of key manipulations as if he were operating an ordinary electronic calculator.

A relatively new machine, the Compucorp 324G,* will perform such routines and run a very high program-step-to-memory ratio, presently 8:1, and will present 10-digit results! The sophistication of the programming is left to the imagination of the user. The machine actually processes to the 13th digit although only presenting 10 – with no apologies being offered to users of the IBM-360 or to equally serious programming with ordinary single-precision results.

elementary programming

Without attempting to go into an elaborate computer course, one or two no-no functions apply equally to the Compucorp 324G and the big IBM jobs; and the first of these is multiplication or division by zero. This is another way of saying that the memory registers should be loaded *before* inputing a program, else the idiot symbol, such as *E----*, will appear. There are ways of getting around this and the procedure will be explained later. Another no-no is attempting to take the square root of a negative number, in which case the result is identical. In both cases the RESET button is convenient, and forgiveness is instant.

Before explaining how you might wind up in either of the above situations, a brief explanation on how to form a loop is given. We have always been accustomed to using the equal sign (=) in expressions such as 2 + 3 = 5. Think of this idea in another context: "I have taken 2 and added 3 and replaced it by 5." Both statements are the same since I am no longer interested in the 2 or the 3, but in my future thoughts I now have 5. I could do the same thing on the machine if I had a 2 in the program, recalled a 3 from a memory register, took the sum, and placed the 5 back in the memory register formerly occupied by the 3. The next time around I might add 2 again, and I would recall the 5 from the register and put the sum 7 back into the same register, and so on.

some examples

The above was a simple exercise in repetition, which may be included in a program as a stepping function. A typical example would be in the design of a directional antenna where you want to obtain a value of field intensity for every five degrees of azimuth. The above routine would be placed either at the beginning or the end of the program, storing the azimuth value in one of the registers and including the quantity for each successive step either in the program itself, or in one of the other registers. Each time the START button is pressed, the value in the register containing the azimuth would step forward, and the calculator would compute

*Marketed in the United States and Canada by Monroe Business Machines

Several years ago *ham radio* published a rather whimsical article about how computers might someday influence amateur radio.* The author made a prediction that has now become a reality: low-cost calculators for home use. In a later issue we presented an article by another author, who described a method of circuit analysis using a canned program, ECAP, but which required large machines such as the IBM 1620.† Here's yet another offering on solving electronic design problems using the computer. Only this time the machine is one of the relatively low-cost minicomputers known as a programmable calculator. Author Aylor leads you through the action in a step-by-step fashion (with advice on avoiding pitfalls) from initial programming to the final result – all on the new Compucorp 324G. Time has indeed marched on. **Editor**

*Louis E. Frenzel, W5TOM, "Computers and Ham Radio," *ham radio*, March, 1969.

†M.A. Ellis, K1ORV, "Computer-Aided Circuit Analysis," *ham radio*, August, 1970.

the new value of field intensity at the new azimuth. Don't forget that you can recall the stored number from your controlling (azimuth) register as many times as you wish with the RECALL button, and the value will not be destroyed until you use the STORE key.

The stepping function, which is incorporated in a loop, is by no means confined to additive quantities. In the directional antenna example you could have as easily started at 360 degrees (or 180 degrees for that matter) and used the subtractive form of stepping; i.e., taking away 5 degrees each time the function was repeated.

Stepping to form a loop is by no means confined to any specific part of an equation. For convenience, the Compucorp 324G micro-computer has a set of parenthesis or brackets and you can form a stepping loop within these boundaries if desired. There is one additional no-no associated with the use of these: you must always use the same number of closing parentheses as used for entrance. Failure to do this will get you that great big error *E----* signal, and only use of the reset button will clear the machine. Once that signal comes up, the reset button is the only key on the board that will work. Moral: get it in right next time.

using parenthesis

Here's a specific example of a short program with an internal loop. In this instance, the stepping function will be

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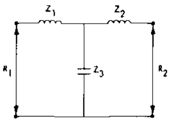
PROGRAM	
DERIVATION OF BRANCH REACTANCES FOR A MATCHING T NETWORK (SEE ALSO 8807471-B)	Program No 8807471-A Models 324 Date 3/74 Author Aylor

DESCRIPTION

This program derives branch reactances in a T network, to match given input and load resistances for a given phase shift. Thus, one may change ratios and phase shifts as desired to obtain network characteristics.



$$Z_1 = -j\,\frac{R_1 \cos\phi - \sqrt{R_1 R_2}}{\sin\phi}$$

$$Z_2 = -j\,\frac{R_2 \cos\phi - \sqrt{R_1 R_2}}{\sin\phi}$$

$$Z_3 = -j\,\frac{\sqrt{R_1 R_2}}{\sin\phi}$$

where:

R_1 = Generator resistance, ohms
R_2 = Load resistance, ohms
ϕ = Phase shift, degrees
Z_1, Z_2 and Z_3 are leg reactances in ohms

EXAMPLE AND TEST PROBLEM:

Find the values of Z_1, Z_2, and Z_3 required to match a generator (R_1) whose output impedance is 50 ohms to a load (R_2) of 75 ohms for the resistive case where ϕ = 70°.

1. Follow loading instructions on reverse side

2. Enter / Press

Enter	Press	
50	ST 1	Input
75	ST 2	Output
70	ST 3	Phase shift
	S/S	

3. -65.16 displays

Press	Read	Description
RCL 7	46.96	Reactance of Z_1
RCL 8	37.86	Reactance of Z_2
RCL 9	-65.16	Reactance of Z_3

Program Number 8807471-A Page 2 of 2

OPERATING INSTRUCTIONS

Loading the Program

1. Enter 1 ST 3
2. Switch to LOAD , PROG I
3. Key in program
4. Switch to RUN
5. Set DP as desired

Running the Program

6. Enter and store the variables as required:

Enter	Press
R_1 (ohms)	ST 1
R_2 (ohms)	ST 2
ϕ (degrees)	ST 3

7. Press S/S Z_3 displays

8. To Read / Press

To Read	Press
Z_1	RCL 7
Z_2	RCL 8
Z_3	RCL 9

Note: This program yields the reactive values in ohms. Program B determines actual values in microhenries (H) and picofarads (pFd) to construct the network, retrieving values in registers 7, 8 and 9.

REGISTER

0	1	2	3	4	5	6	7	8	9	F2
	R_1	R_2	ϕ				Z_1	Z_2	Z_3	

PROGRAM STEPS

1	RSET	41	RCL
2	RCL	42	6
3	1	43	=
4	X	44	DIV
5	RCL	45	RCL
6	2	46	4
7	=	47	CHSN
8	SQRT	48	=
9	ST	49	ST
10	6	50	8
11	RCL	51	RCL
12	3	52	6
13	SIN	53	DIV
14	ST	54	RCL
15	4	55	4
16	F2	56	CHSN
17	ST	57	=
18	5	58	ST
19	X	59	9
20	RCL	60	S/S
21	1	61	
22	=	62	
23	-	63	
24	RCL	64	
25	6	65	
26	=	66	
27	DIV	67	
28	RCL	68	
29	4	69	
30	=	70	
31	CHSN	71	
32	ST	72	
33	7	73	
34	RCL	74	
35	2	75	
36	X	76	
37	RCL	77	
38	5	78	
39	=	79	
40	-	80	

fig. 1. Part A of a program for use with Compucorp 320-series programmable calculators to solve a typical problem: finding component values for a T-network. Page 1, left, presents the problem, shows data to be entered into the machine, and shows the network reactances obtained from the program steps on page 2, right*.

*The equations for Z1, reactance of the input leg; Z2, reactance of the output leg; and Z3, reactance of the shunt coupling mesh; are as presented in F.E. Terman's *Radio Engineer's Handbook*, McGraw-Hill, New York, 1943, page 212 (equation series 113).

enclosed within parenthesis, which stipulate the power to which a number will be raised. This is the old "double-each-day" routine. You've heard the one of going to work for only a penny a day and having your wages doubled every day and so on until you make it rich. The equation for this exercise is day's pay = $2^{(N+1)}$ x 0.01. Let's see how to form a loop with the Compucorp 324G.

First go to RESET, which clears the display, then switch to LOAD and the machine is ready to receive the program. Then proceed as follows:

action	explanation
Punch 2	Installs the integer to be raised to (N + 1) (program starts).
A^x	Instructs the machine that the next expression will be raised to a power.
(	Entrance parenthesis.
1	Incrementing step, once per day.
+	Addition command.
RCL_n	Prepares machine to go into memory register on next stroke.
0	Memory register stored under key 0, reads, and presents sum.
=	Prepares for storage.
ST_n	Alerts for next stroke, which will put selected number under next key punched.
0	Destroys that which was previously in register 0 and puts in a new quantity, N + 1, which is the stepping function.
)	Closing parenthesis. The quantity (N + 1) is now poised and ready for action because you conditioned the machine with A^x earlier.
=	This is the go-ahead for the machine to raise 2 to the (N + 1) power. Remember, the original was raised to an increasing power each day.
X	Multiply command. You must convert whole numbers to pennies and dollars.
.01	One hundred cents per dollar.
=	Presents final result.
START/ STOP	Halts program.
RESET	Clears display to all zeros.
RUN	Terminates and conditions computer for RUN mode.

Now let's see what we've done. The calculator is capable of storing up to 80 steps or operations, and the display presents a running account of each time you press the key. Although there are only 17 *apparent* actions before the switch to RUN, the above storage actually consumed 20 of the 80 available steps. Why? Because, near the end of the program, entering .01 to convert cents to dollars required three key operations – the decimal, the zero and the one. The last step is actually a switch operation and does not count as a step.

We are now ready for a step test. For exactness we store a zero to obliterate anything remaining from the program entry operation, then press START/STOP and the machine momentarily displays a 1, meaning the first day has passed. The machine pauses and presents .02. Press START/STOP again and the machine displays a 2, pauses, then presents .04, and so on. After pressing START/STOP twenty-four times, the answer will be 167,772.16, or in hard Uncle-Sam-type greenbacks, $167,772.16 – not bad for a day's pay after only twenty-four days on the job!

additional looping forms

The example above was a rather simple one in a relatively common exercise. Earlier we used an example of destructive replacement in the 2 + 3 = 5 procedure, and that is exactly what we are doing here. In this example we installed the stepping increment (the fourth action), and on the sixth and seventh action we retrieved the quantity stored in register 0. The moment we punched the EQUAL button, the program added 1 to the quantity retrieved. Thus added, we are no longer interested in the quantity stored in register 0 so we use the storage key (ST_n) and store the new, added value in register 0.

To review, you went into register 0, retrieved what was there, added 1 to it, used it in the calculation, then destroyed it by placing a new number as a replacement into that register, which previously contained the old number. All you did was replace the old value of N with a new value, defined as N + 1.

The rest is simple: put in a closing bracket and you have the portion of the equation shown as a power all set to go.

The Monroe 324G Scientist programmable calculator used by the author.

The calculator has been patiently waiting, poised since you told it that you were going to raise 2 to a power in the first and second steps of the program. Obviously, all that is necessary now is to punch the equal button – calculation gets under way immediately. The rest of the procedure places the decimal point, presents the result, and stops the calculation. Omission of START/STOP, a *common* mistake, will allow the machine to run wild until it hangs up on some value with more than 99 values or figures presented as an exponent in scientific notation.

There are other variations that are somewhat more sophisticated but easily worked on the machine. Suppose you want to construct a map and keep the longitude constant while walking up the curvature of the earth with a stepping value and reach a distance and bearing for each intercept – or suppose you want to construct a tower guy anchor (actually a large block of concrete) and given the weight requirement, you must know the most economical dimensions for placement. Or suppose you must design a transmission line-to-antenna network while solving for all phase shift values. The rule is the same: store it, recall it, and sum it in presentation. Store the presentation in the same register that kills the old value by destructive replacement and let the remainder of the program do the spade work, then go on from there.

There are a few other routines that will become apparent as the user gets more familiar with the use of the machine. For example, the Wayne-Kerr balanced impedance bridge, which is manufactured in Great Britain, gives a reading of the equivalent parallel circuit in terms of millimhos conductance shunted by equivalent picofarads susceptance, and the instruction book gives the equations for conversion. The equations are basic, requiring the conversion of the susceptance to reactance at a specified frequency.

Now, the condition where the susceptance dial reads zero picofarads is very real and means that the load is purely resistive, a function of the conductance. If, during the course of the factoring, the calculator encounters a zero in the denominator, it will latch up on the error signal. The way to avoid this is to input a small additive constant, such as 0.1×10^{-30}, into the capacitance value within the program. The machine adds the zero capacitance to the 0.1×10^{-30} picofarads residual, and the sin committed never shows on 10-place results. Of course, it would have been easier to have inverted the conductance with the 1/X button and ignored the capacitance reading. But the objective is to achieve a program that will work with any list of data you use, with an answer (meaning no error latch-up) on anything you insert, and this means *no* exceptions.

Although taking the square root of a negative number was introduced as a no-no at the beginning of this article, there may be an exception in certain problems where you are stepping one or more variables in a multiplication form and wish to compare the product with a constant that is the criteria beyond which you cannot go. This constant is stored in another register. You then arrange to subtract the product from the constant and take the difference, then promptly take the square root. When the calculator attempts to go past the boundary condition – you guessed it: *error*! It's easy to reset and then recall the values that caused the latch-up. Note that earlier mention was made of dimensioning a large block of concrete to use as a guy anchor for a tower. With concrete costing $150 to $200 a cubic yard in place, overdesign can be costly and underdesign can be disastrous!

a typical program

The discussion that follows is specifically arranged for the Compucorp 324G minicomputer and consists of two programs that can be stored under a single bank of memory registers. The programs are typical of problems encountered in electronics; in this case it's desired to find the inductance and capacitance of a T-network between a generator (usually 50 ohms but subject to the user's choice) and a load such as an antenna, where any impedance may be encountered.

Both programs (**fig. 1** and **2**) are based on standard handbook equations. Program 1 yields the impedance of the three arms of the network. Program 2, into which the desired frequency is entered, gives the network values in μH and pF. In running the programs it's easy to plug in variables, store a value associated with program 1, then give the machine the go-ahead by pressing the START/STOP key. Then you switch to program 2, the machine retrieves the impedance values stored in program 1 and, using the frequency value entered in program 2, converts and displays the network numbers in microhenries and picofarads. Stepping is not included, but plenty of room exists in program 1 at step 60 to recall any values from the first three registers and add the steps in place of S/S (START/STOP) using the same old rule: recall, add (or subtract), store, punch S/S, and be prepared to process again.

analysis

Now let's see what went on in part 1 of the program. The expression under the radical was recalled and multiplied, the square root extracted and put to rest in register 6 at step 10 (**fig. 1B**). Then you recalled the phase shift from register 3, took the sine and promptly stored it into register 4 at step 15 for later use. Next you obtained the cosine with the second function (F2) button and stored it into register 5; but while it was available, you multiplied by the input impedance from register 1 and hit the equal (=) button for the product, then subtracted from the square-root quantity you had stored into register 6 at step 10.

At step 28 you came back for the sine you put into register 4 and divided, switched the sign in step 31, and put the input leg of the network into register 7 on step 33. The same process, with the stored quantities (sine Ø and cosine Ø) and the value under the radical, is repeated, which takes you up to step 50, yielding the output leg impedance. The shunt, or mesh, leg value is obtained by dividing the number under the radical by the sine, which is entered into register 9. Registers 7, 8 and 9 now have input, output, and shunt leg values respectively; program 1 is concluded with START/STOP; and you switch back to RUN.

Program 2 is for those allergic to reactance tables and only requires 40 steps. The microcomputer is switched to eters in impedances and phase shift. With further recalling, registers 7, 8 and 9 have the reactance values, and recalling 4, 5, and 6 gives you the design value of each component. Don't forget register 0 down in the left-hand corner, which contains the frequency.

At this point, if you want to make changes in any parameter in registers 0,

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Page 1 of 2

PROGRAM	
DERIVATION OF ELEMENT VALUES FROM REACTANCE VALUES FOR A T NETWORK (SEE ALSO 8807471-A)	Program No 8807471-B
	Models 324
	Date 3/74
	Author Aylor

DESCRIPTION

This program derives the component values in a T network from the given reactance values independently, or as calculated by Program A.

FEATURES:

- The program is capable of specifying component values for any frequency desired (frequency entered in MHz).
- All unit conversions to microhenries and picofarads are provided for in the program.

EXAMPLE AND TEST PROBLEM:

Having determined reactive values for transfer from 50 to 75 ohms at θ - 70° to be Z_1 = 46.96, Z_2 = 37.86, and Z_3 = -65.16Ω, find network component values for f_o - 1.25 MHz.

1. Enter / Press / Description

Enter	Press	Description
1.25	ST 0	Frequency in MHz
If Program A has not been used, only then,		
46.96	ST 7	Z_1
37.86	ST 8	Z_2
-65.16	ST 9	Z_3

2. Follow loading instructions on reverse side
3. Press S/S. 1953.80 displays
4. To Read / Press / Answers

To Read	Press	Answers
Z_1	RCL 4	5.98 in microhenries
Z_2	RCL 5	4.82 in microhenries
Z_3	RCL 6	1953.80 in picofarads

Program Number 8807471-B Page 2 of 2

OPERATING INSTRUCTIONS

Loading the Program

1. Enter 1 ST 0
2. Switch to LOAD, PROG 2
3. Key in program
4. Switch to RUN
5. Set DP as desired

Running the Program

6. Enter and store the variables:

Enter	Press
f_o (MHz)	ST 0
If used without Program A, then	
Z_1 (ohms)	ST 7
Z_2 (ohms)	ST 8
Z_3 (ohms)	ST 9

7. Press S/S Z_3 displays
8. To Read / Press

To Read	Press
Z_1	RCL 4
Z_2	RCL 5
Z_3	RCL 6

REGISTER

0	1	2	3	4	5	6	7	8	9	F2
f_o				Z_1	Z_2	Z_3	Z_{1i}	Z_{2i}	Z_{3i}	

PROGRAM STEPS

1	RSET	41	
2	RCL	42	
3	0	43	
4	X	44	
5	PI	45	
6	X	46	
7	2	47	
8	=	48	
9	ST	49	
10	4	50	
11	X	51	
12	RCL	52	
13	9	53	
14	=	54	
15	1/X	55	
16	X	56	
17	1	57	
18	EXP	58	
19	6	59	
20	=	60	
21	CHSN	61	
22	ST	62	
23	6	63	
24	RCL	64	
25	8	65	
26	DIV	66	
27	RCL	67	
28	4	68	
29	=	69	
30	ST	70	
31	5	71	
32	RCL	72	
33	7	73	
34	DIV	74	
35	RCL	75	
36	4	76	
37	=	77	
38	ST	78	
39	4	79	
40	S/S	80	

fig. 2. Part B of T-network design program which uses the results of the program shown in fig. 1 to calculate the actual network inductance and capacitance values.

program 2. Examination of the procedure shows that you recalled the values in registers 7, 8, and 9 then calculated the component sizes to produce the new values and stored them into registers 4, 5 and 6, which had been used in program 1 but are no longer needed – a case in point to illustrate destructive replacement.

In considering the 3x3 portion of the keyboard of the 324G microcomputer, you have a complete grid under the nine registers. Using the recall button registers 1, 2, and 3 have the design param- 1, 2, or 3 we can enter or store the new value in the register, switch to program 1, hit START/STOP, then switch to program 2, hit S/S again, and you will have an entirely new and different set of network values. The program described applies not only to matching antenna impedances but may be used for intermediate or output stages of transmitters, delay lines, or any problem of a similar nature in impedance matching. The designer always has control of the parameters he enters, and he may wish to make a number of trials before deciding on the most economically feasible set of final components.

You might ask, "What does all this buy me?" On the presumption that you've followed the previous paragraphs and understand the manipulation or game plan, it's only a jump upward into BASIC or FORTRAN IV. You've already learned an elementary form of assembly language.

final remarks

The average reader will find it's easy to generate programs within a very short time. There's really nothing complicated if a few simple ground rules are observed; i.e., start as deeply within the equation as possible, attacking the constants, and store for recall after the variables have been processed. As stated earlier, use the various registers for short storage, enter, kill, or substitute as you manipulate your way out. If you want to pause to read intermediate data, it's as easy as pressing the START/STOP button, but be wary of using this mode too often since you and the machine may become out of phase. When you want to bracket something, a set of parenthesis is available, which can be doubled if you want.

A little green man is inside the machine to count the number of entrance parentheses and make sure you use the same number of closed parentheses before you terminate the program. He's the same fellow who places the machine in lock-up if you violate any of the rules; but forgiveness is instant with the reset button, and you are permitted to start over again.

Programming and debugging come only with practice. There are all kinds of tricks that an operator will develop on any computer, whether using the simple program presented here or one on the big IBM-360 or IBM-370. The union of man and machine occurs only when one plus one functions as one!

ham radio

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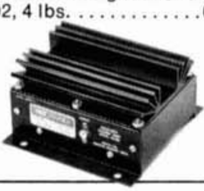

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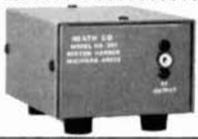

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$$*\text{SINAD} = \frac{\text{Signal + noise + distortion}}{\text{Noise + distortion}}$$

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INSTRUMENTS ROUNDTABLE

Bob Ashton
Instruments Design Engineer
K9EQB/8

The INSTRUMENTS ROUNDTABLE presents tips from the Heath technical staff to simplify your measurements. Many different Heath instruments will be covered in future issues, often by the engineers who designed them. Your comments and suggestions are welcome. The following questions reflect some measurement problems with oscilloscopes.

Q. *How can I make accurate measurements in applications where the oscilloscope input impedance loads the circuits under test?*

A. Use a low-capacitance scope probe such as the *Heath PKW-101. Be sure to consider the attenuation* factor of the probe when making voltage measurements. Also, remember to compensate the probe for your scope's input capacitance to insure accuracy over the frequency range.

Q. How can I tell if a waveform or a segment of a waveform is an exact multiple of the power line frequency (60 Hz)?

A. The easiest way to check is to switch your scope's trigger select control to the "line" position. If the waveform or a segment of the waveform stops its horizontal movement across the screen, it is an exact multiple of the power line frequency.

Q. How can I tell if my transmitter is putting out harmonics?

A. You can use your scope if the transmitter frequency does not exceed the useful bandwidth of your scope. Connect a loop of wire at the end of a probe and place it near the tank or antenna connection. If the sine *wave pattern displayed has "wrinkles" in it, there may* be harmonics present. At slower sweep speeds these wrinkles look like light and dark horizontal lines through the raster.

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TE-321

electronic bias switching for linear amplifiers

A simple electronic vox biasing circuit that lowers quiescent plate dissipation of linear power amplifiers

Marv Gonsior, W6VFR, 418 El Adobe Place, Fullerton, California 92635

The use and value of an electronic bias switch has been known for some time, having been introduced in the popular ETO Alpha 70/77 linears. Bryant subsequently published an excellent version of that circuit in *QST*.[1] It has significant application in two-kilowatt PEP input class-B and class-AB1 linear amplifiers where, especially in the latter, nominally two-thirds of the total plate dissipation is required in the quiescent state for best linearity.[2] This immediately gives rise to the impact of such a device as a means of reducing tube dissipation, the accompanying heat, the ambient noise, as well as lengthening tube life and saving some of your power bill. One further consideration is the possibility of reducing the fan speed, its resultant noise and power consumption. Also, the high class-AB1 idling current is no longer a problem, permitting greater linearity.

circuit

Basically, the bias switch data and background were well covered by Bryant, and served as an excellent basis for a modified design to fulfill my particular requirements, which I prefer to call *Electronic Vox Biasing*, or as a friend dubbed it, a *Vox Box*. That more accurately describes the action of my circuit shown in **fig. 1**. This was, I felt, necessary because the original circuits were much too fast, resulting in a very harsh vox-like action, especially on the make of the switch, and other operating time constants, which were far too short, giving rise to what might be described as a paper-crunching sound, especially at the end of a sentence during ssb operation. For CW break-in operation, however, it would be very effective.

The problem centered on how to slow down an inherently fast circuit due to the saturation characteristics of the transistors resulting from the high current gain of the Darlington configuration. After considerable work an integrator circuit, consisting of C3 and R3, was finally developed which allowed for a softer make that provided an almost indiscernable operation of the switch. The speed on the make, or ris time of the switch, was changed by a factor of 20, from 2 to 40 *milliseconds*. The decay time of 140 milliseconds is no problem at all since C2 and R2 may be easily altered to any required time constant.

It should be recognized that the quiescent bias voltage itself at point A in **fig. 1** *supplies* V_{cc} *to the Darlington* pair. This is the self-bias developed by current, I_p, drawn by the cathode holds it in operation in its active mode. In my particular case, the voltage at point A varies from 55 volts to 0.7 volt (the $V_{ce(sat)}$). Depending upon the particular operating biases and the tube used in the linear amplifier, the quiescent bias voltage will vary. Since, for the reasons *stated above*, the switch will only operate when it is installed in the cathode

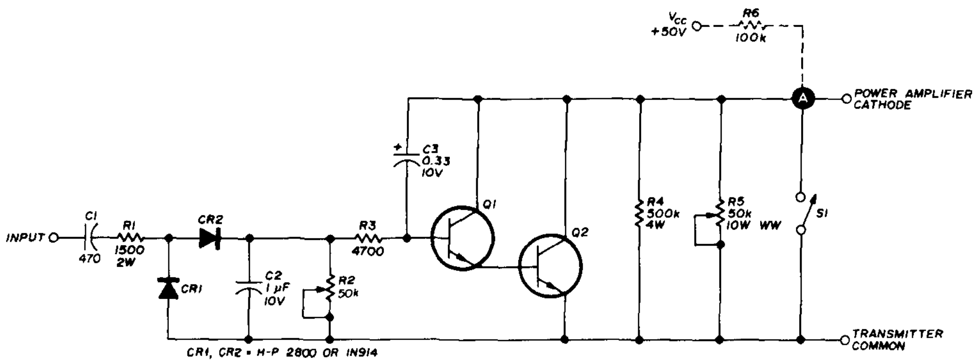


fig. 1. Electronic vox biasing circuit. The transistors used for Q1 and Q2 depend upon the cathode voltage of the power amplifier tube (see table 1). Adjust C1, R1 for drive level. Switch S1 permits establishing operating point for class-AB1 amplifiers and is used as operating switch in case of bias circuit failure.

the cathode current across resistor R5, which becomes ordinary center-tap bias on the amplifier. The system operation becomes *apparent as an electronic* normally-open spst relay which removes the unwanted self-bias in its closed state with appropriate time constants.

As has been shown, the Darlington pair has its V_{cc} supplied by the cathode voltage in its quiescent mode. The plate

table 1. Transistors for the electronic vox biasing circuit.

	output voltage ≤50 Vdc	output voltage 50-125 Vdc	output voltage 50-125 Vdc
Q1	2N5681 (TO-5)	2N3439 (TO-5)	2N3439 (TO-5)
		2N3440 (TO-5)	2N3440 (TO-5)
Q2*	2N5681 (TO-5)	2N3439 (TO-5)	2N6262 (TO-3)
		2N3440 (TO-5)	2N6354 (TO-3)
			RCA411 (TO-3)
			DTS423 (TO-3)

*Use heatsink with TO-5 devices

circuit, for independent test it is necessary to temporarily supply the V_{cc} separately through a 100k limiting resistor, R6, to point A.

Table 1 outlines the various switching devices which will satisfy the requirements for Q1 and Q2 with V_{ceo} ratings greater than 100 volts. Further, a heatsink such as an *IERC* type *UPTO-3* may be added to transistor Q2 which *will considerably extend its 100-watt* power dissipation. The heatsink, used in combination with the necessary heat-conducting grease, will satisfy the most demanding requirement.

The serious designer could consider a total redesign of the circuit starting with an op-amp shaper driving a transistor as a voltage follower, rather than the Darlington configuration. This would provide complete control of the rise and decay times. This will be something for a future project.

construction

I built my electronic vox biasing circuit on one-sided, copper-clad Vector board as shown in **fig. 2**. It only took a couple of hours to build, and could be done in less time if an unclad board were used since a good ground plane is apparently not required. Parts location is very noncritical and no problems were encountered with any instability, etcetera. Switch S1 may be a miniature relay, as I used, or a simple spdt toggle switch to short the bias switch to set the proper operating quiescent current, I_p, or to eliminate the switch in case of an open-type failure.

In the case of a shorting-type failure, the electronic vox biasing circuit will hold I_p to its normal switched value of 0.7 volt, i.e., essentially zero biasing. In the event resistor R5 were to open up, resistor R4 will prevent the full plate voltage from appearing on the cathode. These fail-safe precautions are in order for obvious reasons and will provide the user with a reasonable amount of voltage and dissipation security, since the total I_p flows through transistor Q2 along with the aforementioned high voltage risk.

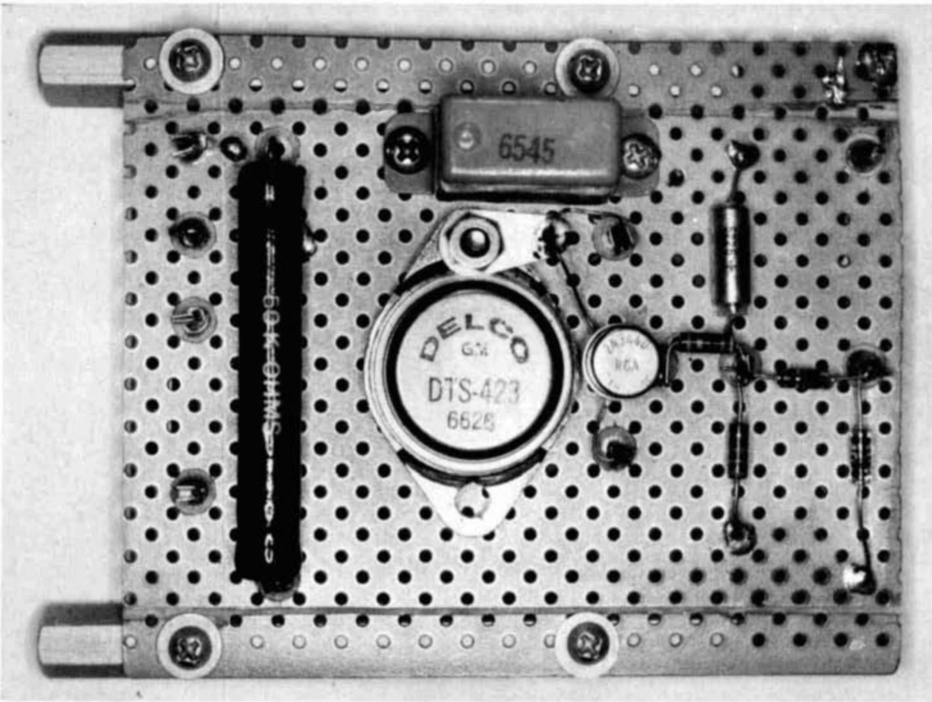


fig. 2. Construction of the electronic vox biasing circuit built by W6VFR. Although copper-clad perf board is shown here, a ground plane is not necessary, and since parts placement is noncritical point-to-point wiring is satisfactory.

Fig. 4 depicts the switch operation at a half-second sweep speed, with a male voice saying, "one, two, three, four." **Fig. 5**, at the same sweep speed, depicts the word, "four." As may be seen, the switching speed looks much like conventional CW keying time constants.

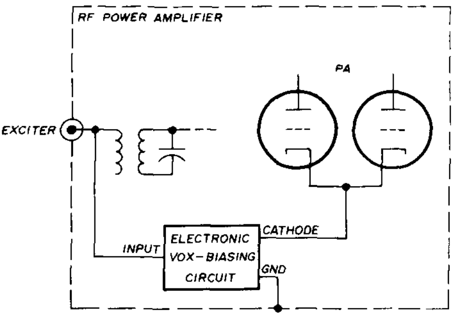


fig. 3. Typical application for the electronic bias-switching circuit. In rf power amplifiers using directly-heated tubes (such as the 3-500Z), the cathode output of the bias-switching circuit is connected to the center-tap of the filament transformer.

A few words are in order regarding the *time constants. Resistor R2, in* combination with C2, basically establishes the decay time of the switch with some interaction with the make time. Capacitor C3 in combination with R3 affects the make and the break, while the combination of R1 and C1 establishes the keying sensitivity and the hold time. These should be set for the reliable operation of the switch at the highest frequency of operation and at the lowest anticipated power level.

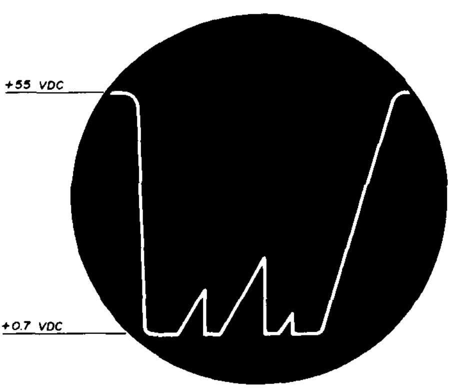


fig. 4. Oscilloscope display of electronic vox biasing circuit voltage output with male voice saying, "1, 2, 3, 4." Sweep speed is 0.5 second.

A dc-coupled scope is highly recommended for adjustment for all time constants, bearing in mind that the current gains of the semiconductors and variations in component values will alter the result to some degree. All of my timing measurements were made on a H-P 1220A oscilloscope. At 14 MHz, the keyer will reliably turn on completely at 0.5 volt rms as indicated on the output meter of a Measurements Corporation model 65B signal generator and verified with the oscilloscope.

The results of numerous on-the-air tests, both under local and skip condi-

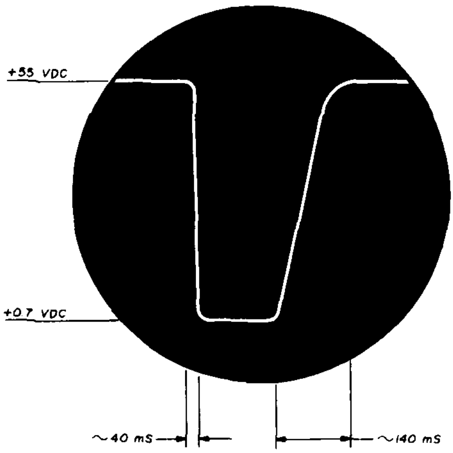


fig. 5. Oscilloscope display of electronic vox biasing circuit voltage output with male voice saying, "four." Sweep speed is 0.5 second.

tions, indicate little or no perceptible switching action, and a 32°F temperature *reduction* in the outlet air tempera*ture of my linear amplifier. This,* at 55 cfm air flow, calculates to a 520 watt *average* power reduction, a well worthwhile improvement by any criteria.

references

1. J.A. Bryant, W4UX, "Electronic Bias Switching for RF Power Amplifiers," *QST*, May, 1974, page 36.
2. *Linear Amplifier and SSB Service Bulletin 12*, Eimac, San Carlos, California, 1966.

ham radio

low-power dc-dc converter

A simple transformerless dc-dc converter circuit which may be used for those applications where you need a separate low-current supply

Gail A. Graham, W5MLY, 1003 Wade Street NE, Albuquerque, New Mexico

When designing electronic systems around ac power, an additional supply voltage seldom represents any problem. For low power an additional rectifier and/or regulator will often suffice, and worst case means the addition of a small transformer. When mobile operation is considered the problem becomes more difficult. If the requirement is for a voltage of the same polarity and lower than that of the automobile battery, then a simple voltage regulator will do the job. However, if you need a voltage that is higher or of opposite polarity than the vehicle battery, then something more elaborate is indicated. Occasionally it is possible to obtain power from an existing converter and suitably regulate it, but with more and more equipment being designed for direct 12-volt operation this option is fast disappearing.

The transformerless dc-dc converter described here may be adapted to a variety of low-power applications requiring voltages either higher or of opposite polarity than the vehicle battery. This power supply may also find some application as an on-card supply in fixed installations. As a negative voltage supply it may be used to power linear ICs such as operational amplifiers. By

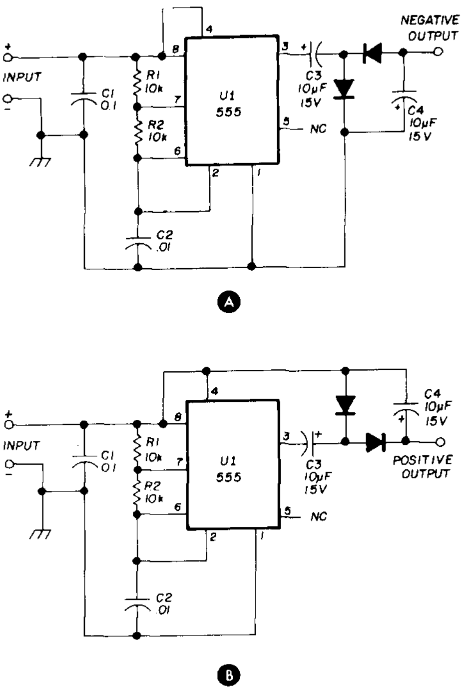


fig. 1. Low-power dc-dc converter may be used to supply negative voltages (A) or positive voltages of greater value than the input (B). For positive-ground systems, allow the ground shown in these circuits to float. Voltage-current capabilities of these circuits are listed in table 1. All diodes are 1N914, 1N4148 or equivalent.

using the vehicle battery as the positive supply and the dc-dc converter for the negative supply, signals may be referenced to the vehicle ground. This is very convenient, especially in control applications. As a voltage booster supplying voltage of the same polarity but of a higher potential it provides a convenient source for such things as trickle charging 12-volt nickel-cadmium batteries.

The basic negative converter is shown in **fig. 1A** and the positive booster shown in **fig. 1B**. **Fig. 2** shows how additional diode-capacitor voltage-doubler sections may be added to increase the voltage output of the positive voltage booster (at the expense of available current). The same principle may also be applied to the circuit of **fig. 1A** to produce negative voltages of higher potential. Although all the schematics indicate a negative-ground input power source, positive-ground input may be used by grounding the positive input to U1 and floating the ground shown in **fig. 1** and **2**.

operation

Operation of the dc-dc converter is straight forward. U1 is a 555 timer IC operated as a free-running square-wave oscillator. The 555 makes an ideal oscillator for this application as it requires only three external components for oscillation and the output has the ability to source and sink up to 200 mA without additional buffering. The frequency of operation is determined by R1, R2 and C2 (with the values shown it is approximately 6 kHz). Capacitor C1 is used to reduce the amount of

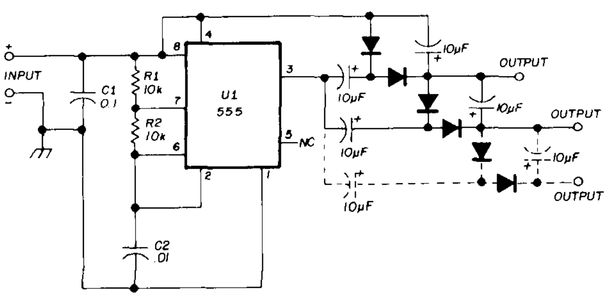


fig. 2. Voltage output from the positive voltage booster (fig. 1B) may be increased by the use of voltage multipliers as shown here. Diodes are 1N914, 1N4148 or equivalent.

6-kHz signal radiated through the input power lines.

Since the switching times of the 555 IC are quite fast, this 6-kHz signal generates harmonics up into the higher high-frequency bands and may be heard on a communications receiver if the switching transients are not filtered. If the dc-dc converter is operated as part of a high-frequency receiver, it may be necessary to insert small (100-μH) rf chokes in the power leads to further reduce these harmonics.

The 6-kHz output at pin 3 of U1 is capacitive coupled by capacitor C3 to a rectifier circuit and filtered. The output filter capacitor, C4, may be increased above the 10 μF value shown if a low ripple content is essential. However, for operating an op-amp or two the amount of ripple with the circuit as shown is not objectional for most simple applications. Voltage-current capabilities for various voltage inputs are listed in **table 1**.

table 1. Voltage-current capabilities of the dc-dc converter shown in fig. 1. For circuit of fig. 1B, add input voltage to output voltage (i.e., 5-volt input with no load, E output = 5 + 3.8 = 8.8 volts).

Input = 5 Vdc	Input = 6 Vdc	Input = 9 Vdc	Input = 12 Vdc
output	output	output	output
3.8V, 0 mA	4.8V, 0 mA	7.7V, 0 mA	8.9V, 2 mA
2.2V, 1 mA	3.2V, 2 mA	6.2V, 1 mA	8.4V, 10 mA
2.1V, 2 mA	3.0V, 4 mA	6.1V, 2 mA	8.1V, 15 mA
2.0V, 3 mA	2.9V, 6 mA	6.0V, 4 mA	7.9V, 20 mA
1.9V, 4 mA	2.7V, 8 mA	5.9V, 6 mA	6.7V, 30 mA
1.9V, 5 mA	1.5V, 10 mA	5.7V, 8 mA	6.1V, 40 mA
1.8V, 6 mA		5.6V, 10 mA	5.7V, 50 mA
0.6V, 7 mA		5.3V, 15 mA	5.5V, 60 mA
		5.0V, 18 mA	5.0V, 70 mA
		4.2V, 20 mA	4.6V, 80 mA*
			4.0V, 90 mA*

*Current exceeds rating of recommended diodes.

construction

Construction of the dc-dc converter is not critical although capacitor C1 should be as close as possible to U1 to reduce radiation of the 6-kHz harmonics. As it is anticipated that the converter will probably be incorporated as part of another circuit board, no PC layout is shown. For prototype applications, however, it may be convenient to build up a few on small PC boards (the supply shown in **fig. 1A** will fit with room to spare on a PC board 3/4-inch wide by 1½-inch long (19x38mm).

ham radio

"I wish I could establish a single transmission for almost three minutes with you."


VHF ENGINEERING

brass pounding on wheels

The saga of Old 1401 — first radio communications from the rolling White House, the presidential train

Charles W. Clemens, Jr., K6OD, 9971 Deerhaven Drive, Santa Ana, California 92705

Many of the operating stories we read in the amateur publications are about sea-going brasspounders. This one is about a brass pounder who rode the rails. Back in the summer of 1942, I was working my shift at WAR in Washington when an officer walked up behind me and tapped me on the shoulder. He told me to go pack my clothes for a trip to a warm climate. That was how I started as the first CW operator at the White House.

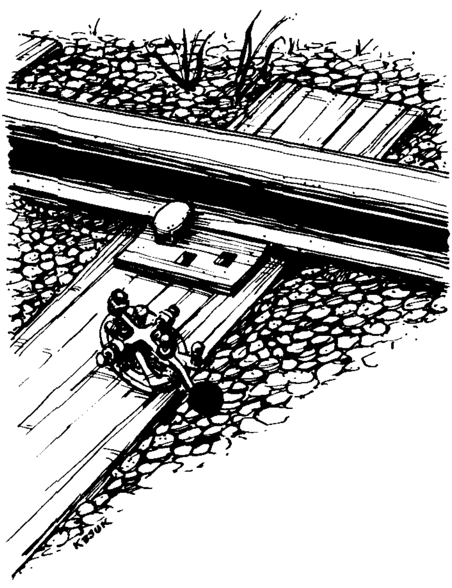
I learned that the White House had a Signal Corps detachment that now had the task of providing communications on a continuous basis between the Presidential Train and the White House. I believe this was the first time such a thing had been attempted in the United States. The Washington end was to be handled by the big War Department communications center, WAR; the remote end by the train plus relays, when necessary, from local stations along the way.

My first trip on the communications car, *Old 1401,* was the second trial run for the car. On this trip I went with the detachment commander, Col. Beasley; a radio operator recently made a Lieutenant, Lt. Greer; a civilian engineer from the War Department named Jack Kelleher; a radio maintenance man named John J. Moran; and a Secret Service man named George J. McNally. It is interesting to note that all of us were amateur radio operators. We went from Washington, D.C. to New Orleans and returned with our car in a regular passenger train, coupled between two baggage cars.

Old 1401 was a *combine car.* That is, she was half baggage and half passenger. She had been built for the Baltimore and Ohio Railroad in 1914. At the time I first met her, all identification on her sides had been painted out. Her number was her only identification, and it was painted in beautiful gilt over the entrance at the passenger end.

Inside, a couple of front seats had been removed and an operating table installed in their place. One operating position was located on each side of the aisle between the seats. Each position had a Super Pro receiver and a BC-342.

The BC-342 was a new model at that time, designed for use in tanks and other rough riding vehicles. This receiver was installed on shock mounts, but my first trip proved that the best way to mount equipment on the train was to bolt it down solidly. Installed in this manner, the whole car moved as one unit and the



receivers worked beautifully. There was, however, a modulation on the received signals imparted by the train's vibration. But this was better than having the tubes jump out of their sockets – which they frequently *did* when the equipment was on shock mounts (the tube clamp was not yet in common use).

Telegraph lines alongside the tracks provided a lot of clicks that made it difficult to copy poor signals. However, we didn't have too much trouble with this problem except in the Southwest. The transmitter was a BC-447, running about 300 watts.

The clearance requirements for railroad cars prohibited using a real antenna. Ours was a wire inside an insulating tube mounted on standoffs about six inches above the metal roof of the car. This was later changed to a copper tube, the same size as the insulating tube, with much better results. Our frequency complement ran from 3 MHz to 17 MHz.

I was supposed to contact a number of Army stations along the way, none of them more than a couple of hundred miles from our route. As might be expected, results were poor and it was decided to contact WAR in Washington direct. Successful contacts were made from New Orleans and on the way home. The only real difficulty came when we were close to Washington. At that time, it was difficult to receive WAR on any frequency. Overall, however, our results were encouraging and we were assigned the task of accompanying President Roosevelt on his swing around the country visiting military bases and aircraft plants.

To my knowledge, this big trip was the first time continuous communications had ever been attempted between the presidential train and Washington. We contacted WAR in the eastern half of the country and WVY (San Francisco) or WVD (Seattle) in the western half. Results were excellent. In fact, our volume of traffic was so high that it was necessary to pick up an additional message clerk in Seattle, our first major stop, to handle the paper work.

To make a long story quite short, I worked six years on the Presidential Train, traveling with Presidents Roosevelt and Truman in the United States, Canada and Mexico. We logged well over a hundred thousand miles.

Equipment and facilities were improved over those years, and when I left *Old 1401* in 1948, the car had a small operating room, a code center, a small bunk room with four bunks, a lounge room, and the baggage half of the car packed with equipment. We had two BC-339 transmitters for our message traffic. These were fixed station Federal jobs that loafed along at 1500 watts in radioteletype service and could easily run 3 kW on CW.

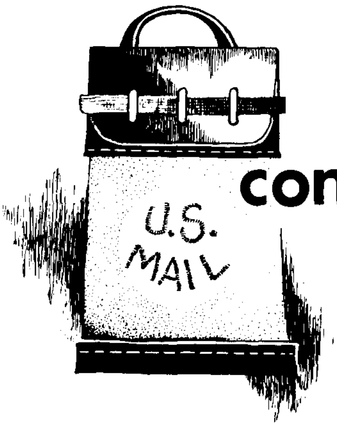
A single BC-610, a 500 watt a-m transmitter, was available for occasional broadcast services. We also had a 250-watt Motorola fm transmitter for guard radio service. On the receive side, we had the two BC342s I mentioned earlier, two Super Pros, a big Navy receiver whose type number I can't recall, two Western Electric CV-31 teletype converters and a single teleprinter.

We also had a telephone switchboard that provided service throughout the train. The telephone cable permitted us to provide music throughout the train and intercom service, too, if it were desired.

Power was provided by two 25-kW diesel generators. Only one of these was required, and we switched them every 24 hours. We also had two 100-amp battery chargers to charge the train's batteries when we were parked away from railroad terminal facilities, and two converters to provide ac power from the batteries to run our receivers in standby.

Today, the train is no more. *Old 1401* has been retired and the President's car – *Ferdinand Magellan* – is gone, too. The small detachment I knew has grown to the White House Communications Agency. Their responsibilities have grown a great many times over. But I'll bet they aren't having any more fun working assignments today than I did when *Old 1401* was my home on wheels.

ham radio



comments

impedance bridges

Dear HR:

I noted the two items on noise bridges in the May, 1974, issue and perhaps my experiences with the two bridges might be useful. First, regarding WB2EGZ's bridge (December, 1970) I had the same problem, i.e. insufficient gain. I solved this by the use of two stages of amplification using the high beta RCA transistor 40245 before going into the balun transformer. This yields a very simple circuit and only a 5 mA drain on the battery, an important point because when making measurements the unit is often run for long periods. Since this bridge measures only the parallel equivalent resistance of the load, the presence of a significant amount of reactance greatly reduces the depth of the null.

The bridge design presented in the January, 1973, issue does measure reactance and consequently the depth of nulls within its range of reactance tuning can be as deep as those obtained with pure resistances. However, I found that the plus/minus 70-pF range for reactance to be inadequate. An examination of the possible capacitive or inductive components encountered around a 2:1 vswr circle on a 50-ohm Smith chart indicates, for example, that if R_{series} = 58.8 ohms and X_{series} = ±38 ohms, the parallel equivalents are R_p = 83.3 ohms and X_p = 129 ohms. This translates into a Cp of ±324 pF at 3.8 MHz or ±88.2 pF at 14 MHz. The consequence is that a bridge capable of reading ±70 pF can only yield information about an antenna on these bands whose vswr is already pretty good. I changed this bridge to use a 365-pF variable (Radio Shack has a small one for $1.95). The 68-pF fixed capacitor then has to be changed to 180 pF. Furthermore, I brought out terminals from these capacitors so that I can add further fixed capacitors as needed.

One point needs emphasis when working with these bridges and Smith charts: these particular bridges read out the parallel equivalents of resistance and reactance, while the Smith chart is designed for the series equivalents. The following series-parallel transformation equations should be kept handy:

$$R_s = \frac{R_p X_p^2}{R_p^2 + X_p^2} \qquad X_s = \frac{R_p^2 X_p}{R_p^2 + X_p^2}$$

$$R_p = R_s + \frac{X_s^2}{R_s} \qquad X_p = X_s + \frac{R_s^2}{X_s}$$

It can also be shown that:

$$\frac{R_p}{X_p} = \frac{X_s}{R_s} = Q$$

One further comment: While the R_p calibration holds pretty well from 3.5 to 30 MHz (paying careful attention to strays), the C_p calibration rotates towards the inductive direction by about 20 pF at 30 MHz for R_p values between 35 and 200 ohms, more so for values under 35 ohms. If the experimenter is using this bridge at 30 MHz or higher it is important that he calibrate the bridge for these frequencies. I found that a calibration made at 3.5 MHz holds pretty well through the 21-MHz band.

Provided one knows the characteristics of the coax line (characteristic impedance, velocity factor, attenuation and electrical length) with this bridge and a Smith chart one can measure the characteristics of an antenna at the shack coax terminal. It is not necessary that the line be an exact half-wave multiple. The assumption that the load characteristics are faithfully represented at the end of a multiple of a half-wavelength transmission line is true only at the exact frequency for which the line is a half-wave multiple (see April, 1974, *QST* article by W2DU). Usually we are interested in what an antenna is doing over part or all of an amateur band and it is important to realize that for frequencies other than the exact half-wave multiple the load is no longer faithfully represented. The error becomes increasingly significant with increasing vswr.

Forrest Gehrke, K2BT
Mt. Lakes, New Jersey

ac current monitor

Dear HR:

The *ham notebook* section of the January, 1974, issue described a line voltage monitor that is very similar to one I have been using for about four years. The differences are slight, but my circuit has fewer components than WA8VFK's version. I didn't feel that the bridge rectifier and filter capacitor were required. If you are willing to accept only a little more non-linearity, a half-wave rectifier with bypass capacitors connected across the diodes and the input are all that is required. Rather than one expensive zener diode, I used three zeners from my junk box which added up to the voltage I needed.

A variable transformer in the ac power to my bench is used to check the performance of various types of equipment for over and under-voltage, and to compensate for line-voltage variations.

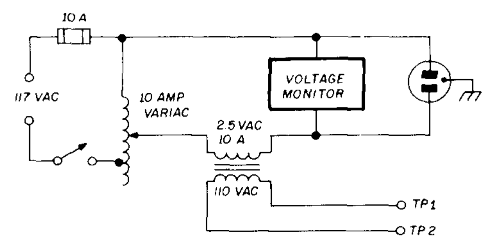


fig. 1. Ac current monitor uses high-current 2.5-volt filament transformer. One amp through 2.5-volt winding yields 11-Vac between TP1 and TP2.

A 2.5-volt, 10-amp transformer in the circuit (see **fig. 1**) is used to provide a readout of ac current on a voltmeter connected across TP1 and TP2. Each ampere of ac current passing through the 2.5-volt winding develops 0.25 volt across the winding – this is transformed to 11 Vac at TP1 and TP2 (1 amp = 11 Vac, 2 amps = 22 Vac, etc.). Any low-voltage, high-current transformer can be used in this application, but the 2.5-volt,10-amp unit is ideal because the transformed voltage is easily interpolated into current (1 volt ≈ 100 mA ac current).

E.G. Sullivant, Jr., WB5MAP
Shreveport, Louisiana

the ham notebook

increased flexibility for the memory keyer

In a recent article WB9FHC described the construction of a two memory electronic keyer.* After using this unit on the air for several weeks, I decided to expand the keyer's capability, permitting greater operating flexibility during contests.

As a first step, I wanted a self-contained keying monitor, particularly for initial off-the-air programming. A simple but effective circuit is shown in **fig. 1**. The circuit uses half of a 7413 dual NAND Schmitt trigger. A miniature 500-ohm pot is used for the tone control, while the inexpensive 8-ohm speaker was salvaged from an old transistor radio. The monitor can be switched out of the circuit when not in use.

Many times during a contest, especially during low activity periods, a message, such as a CQ, is to be repeated a number of times without having to manually recycle the memory each time. A simple solution is to install a spst toggle switch in parallel with S1 of the original circuit. In my particular case, a CQ without the $\overline{AR}$ K ending was desired to nearly fill the 256-bit memory capacity. During programming a stop-watch was used to note the elapsed time of the memory cycle. By careful spacing of the message CQ CQ DX TEST DE K3NEZ K3NEZ, the entire memory can then be filled without any appreciable pause at the end. If the message is to be sent three times, the toggle switch is closed and then opened just after the desired message starts to repeat for the third time. The $\overline{AR}$ K ending is then sent manually with the paddle after the callsign has been sent by the memory.

Since it was desired to add a third, and possibly fourth, 256-bit memory to the keyer, it became apparent that the use of a single rotary switch for selecting the memory was not efficient. The circuit of **fig. 2**, when added to the original circuit, permits the operator to simultaneously select the desired memory and cycle the four-bit counters.

Although three memory units are shown, additional units are easily paralleled, as the circuit is straightforward. A LED indicator is provided for each message. Note that the part of the original circuit from $\overline{Q}$ of 7473C is omitted. For example, to read or write from memory A, simply depress the corresponding switch; otherwise, operation is the same as described in the original article.

Howard M. Berlin, K3NEZ

*Michael Gordon, WB9FHC, "Electronic Keyer with Random-Access Memory," *ham radio*, October, 1973, page 6.

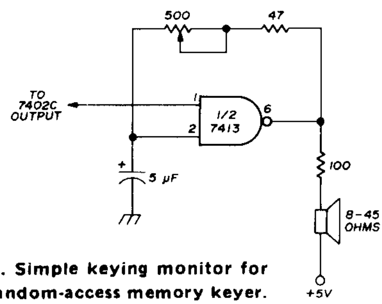


fig. 1. Simple keying monitor for the random-access memory keyer.

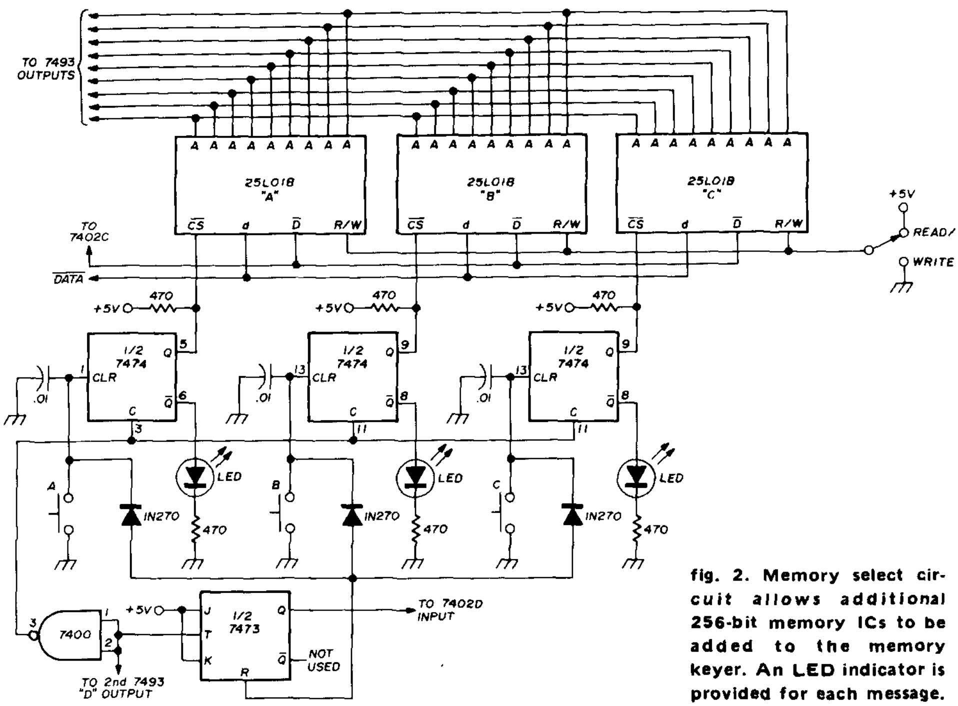


fig. 2. Memory select circuit allows additional 256-bit memory ICs to be added to the memory keyer. An LED indicator is provided for each message.

hi-fi interference

An excellent article on audio-frequency interference in a recent issue of *Radio Communications* discussed problems which are not mentioned in our usual Handbooks.

A simple LC filter was first tried on the bench to keep rf out of the coaxial lead to the audio amplifier, particularly from a record player. The coil turned out to be resonant, so it was not reliable at widely varying frequencies. The capacitor alone, to ground, was usually better. When tried in a Garrard record player, however, which has unshielded pick-up leads connected to phono jacks, *no improvement* was noted.

The rash of hi-fi complaints here results from unidentified CB as well as my own transmissions. The greatest problems were from Garrard players, but to a lesser extent from a Wollensak-3M cartridge player. When all input and output coaxial lines were removed the fm broadcast receiver played without interference, but one a-m tuner had many signal peaks in its tuning range.

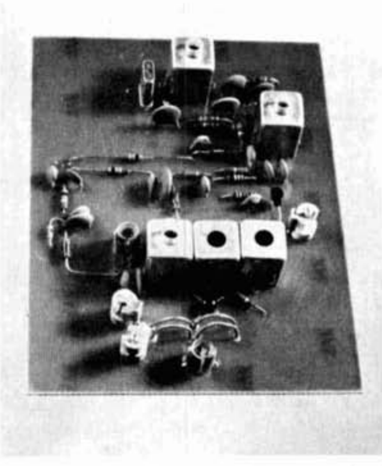
In addition to bypassing audio-amplifier base-emitter junctions with rather large capacitors (1000 pF up), I hope to try the recommended ferrite beads, and to develop lowpass filters to plug into the coaxial input and output lines without creating unacceptable loss of high-frequency audio.

Radio Shack tells me that several *manufacturers have produced filters* which can be inserted in the audio leads from record-players and tape-players to prevent rf pick-up from reaching the audio transistors in the amplifier. These filters are seldom known even to the hi-fi departments of stores, but are available upon request, much as high-pass TVI filters have been available to those who know about them and are familiar with this method of complying with the FCC regulations.

Bill Conklin, K6KA

new products

uhf converter and preamplifier



Hamtronics, Inc., well known for its vhf preamps, receivers and scanners, is moving into the uhf field with two new products. The first is a uhf converter kit, shown above, which operates on the 432- to 450-MHz amateur band or on the rapidly growing 450-470 MHz public safety band. The converter is constructed on a 3x4-inch G-10 board and features a low-noise jfet, high-quality, milled variable capacitors, integral coax connectors, and low current 12-volt operation.

The converter has one built-in oscillaor, and an adapter is available for six additional frequencies for channelized fm operation. It can be built to output on the popular two-meter fm band or 6 meters, 10 meters, commercial bands, etc. Price for the kit is $20, which includes domestic shipping. Add 80¢ for air mail if desired. Crystals are available for any frequency scheme at $5.50.

The second new uhf product is a low-noise preamp kit for 432-450-470 MHz. This unit has features similar to those of the converter. Price is $15 for the kit or $25 wired, including domestic shipping. Add 60¢ for air mail if desired. For more information or to order, write to Hamtronics, Inc., 182 Belmont Road, Rochester, New York 14612.

how to troubleshoot and repair test equipment

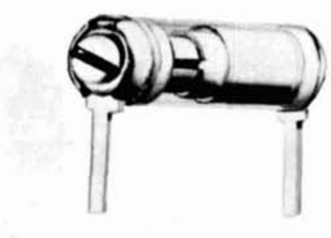
"Cure your own equipment" is the watchword of this brand-new volume, written by Mannie Horowitz, one of the top designers of electronic test equipment. Any competent amateur should be able to repair his own equipment, and it's easier than ever before with this new one-of-kind book! It's jam-packed with practical, ready-to-use data on the repair of power supplies, multimeters, oscilloscopes, audio and rf signal generators, sweep generators and tube and semiconductor testers. No complex math or circuit theory is included – this is *not* a book that requires study, but one that can be used from the very minute it's opened. With the complete, simplified theory that is presented, read-

More Details? CHECK—OFF Page 94

ers with even modest electronic backgrounds will understand equipment as never before, and get more out of using it as well.

For each piece of equipment there is a clear, illustrated explanation of the basic circuits it contains. There's also a complete trouble analysis of each circuit, telling what can go wrong and what the probability of it is. Next comes an explanation of how the basic circuits are integrated into a complete circuit by the switching circuitry. Then, test procedures for an actual example are presented. Published by Tab Books, 252 pages, soft bound, $6.95 from Ham Radio Books, Greenville, New Hampshire 03048.

high-precision trimmer capacitor



A new type of miniature trimmer capacitor claimed to give outstandingly linear response (better than 2%, with no local reversals of capacitance) has been announced by Jackson Brothers of England. The *Trimline* capacitor is a tubular design 5-mm in diameter and 18-mm long. Its contant length simplifies layout planning. Minimum capacitance is below 0.5 pF and maximum is above 5 pF. Adjustment is by screwdriver slot, with ten turns between minimum and maximum to permit very fine setting.

Unlike most tubular trimmers, the *Trimline* employs air as the dielectric, and the moving element does not rotate. This avoids eccentricity and deviations from linear response associated with designs based on a rotating piston. Here the stationary element is a small piston and the moving element is a coaxial cylindrical sleeve. Both are made of silver-plated brass. The sleeve is moved axially by a lead-screw engaging a threaded collet inside it; it is precisely located and guided by a fixed outer glass sleeve, and by two lugs in its tail which run in fixed longitudinal slots.

At both ends of the travel a slipping-clutch mechanism – a patented feature – prevents accidental damage being caused by over-adjustment. At maximum capacitance a Teflon stop prevents electrical shorting. Electrical losses are low (Q factor greater than 1000 at 20 MHz), and the capacitor has an expected life of over 10,000 adjustment cycles. For more information, write to Jackson Brothers' agent, M. Swedgal, 258 Broadway, New York, New York 10007, or use *check-off* on page 94.

tool catalog

A free tool catalog describing over 2500 individual items is offered by Jensen Tools and Alloys. "Tools for Electronic Assembly and Precision Mechanics" is a 112-page handbook of particular interest to electronic technicians, radio amateurs and engineers.

Section headings include screwdrivers, wrenches, pliers, tweezers, files, shears, knives, microtools, relay tools, power tools, metalworking tools, wire strippers, soldering equipment, test equipment, engineering and drafting supplies and electronic chemicals. New sections include metric tools, books and wire-wrapping tools.

Another important feature of the catalog is the inclusion of four pages of technical data on tool selection. Known as "Jensen Tool Tips," these pages include sections on screwdriver selection, machine screw data, tool materials,

More Details? CHECK—OFF Page 94

plier facts, metal conductivity, color coding, wire and insulation data, solderability of metals, temperature conversion, drill sizes, metal gauges, metric conversion and safety. Five pages of "tool terms" are also included.

A free copy of the Jensen catalog may be obtained by writing to Jensen Tools and Alloys, 4117 North 44th Street, Phoenix, Arizona 85018, or by using *check-off* on page 94.

diode applications

Diodes are the simplest yet most versatile devices found in electronic circuits. Typical applications range from power supplies to waveform converters, logic elements, temperature-compensating devices, regulators and signal detectors. This new book by Courtney Hall, WA5SNZ, surveys these and many other important uses for diodes.

In a clear, readable presentation, the book begins with basic information about diode properties and how diodes work. *Vacuum-tube diodes and recti*fiers, semiconductor diodes and diode reverse recovery time are other topics covered in Chapter 1. Chapter 2 discusses rectifier power-supply circuits. Half-wave power supplies, full-wave rectifier circuits, voltage-doubler circuits, transformer ratings and more are explained in depth.

The next chapter covers circuits for ordinary diodes. Beginning with logical OR and AND circuits, it covers the ideal diode, diode gate circuits, flip-flop preset *circuits and diodes for meter protec*tion. Another chapter is devoted to zener diodes. Two chapters are set aside for the newer diode types such as LEDs, tunnel diodes, varactors and semiconductor lasers.

Soft cover, 96 pages, $3.50 from HR Books, Greenville, New Hampshire 03048.

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A popular option designed to plug right in to the ST-6 is HAL's AK-1 AFSK oscillator. Available assembled or in kit form, the AK-1 is an AFSK oscillator that demonstrates stability and reliability. It provides switch selection of 170 Hz and 850 Hz shift using standard AFSK tones. The AK-1 may also be mounted in its own cabinet for use as an independent unit. Frequencies are set by 15-turn trimmers for ease of accurate tone adjustment. The AK-1 operates on 12 VDC, or directly from the ST-6 power supply.

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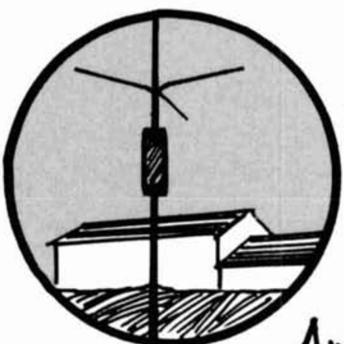

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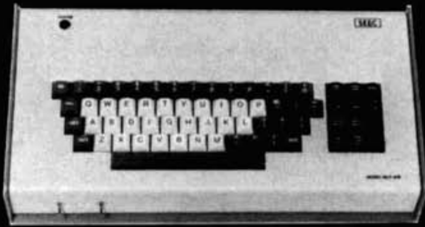

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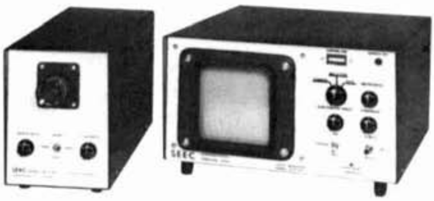

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It works like this—You type the message to be transmitted, plus any comments if you wish, onto the screen. *You can use our KBD-2 keyboard, or* any other ASCII encoded keyboard that you might have available. The characters are stored in a 1,024 bit static semiconductor memory. The format is two pages, or frames, of 16 lines having *up to 32 characters per line. When you are finish*ed, you push the "READ" button on the CT-1024. This causes the cursor to advance through the material on the screen one character at a time and place its ASCII code in the UART portion of the terminal. The UART converts the parallel code to a serial format and passes it on to the interface for transmission. The standard rate is 110 Baud, but 220, 300, 600 and 1200 are available as options.

When you receive, the process is reversed. The UART takes the incoming serial data, converts it to a parallel ASCII code and places the information in memory. The message is displayed on the screen at the same time.

You can also use the CT-1024 with a modem as a time share computer terminal or directly with a CPU as an input device.

Please note that this is a kit. It does not include a cabinet, or chassis. This system is not for the —"plug it in and transmit" crowd. This system is designed for the serious RTTY operator who builds his equipment and wants to use the latest techniques. You will need the first three items below for a system. You may, or may not need the keyboard and power supply, depending on what other equipment you already have on hand.

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flea market

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■ **SEND MATERIAL TO:** Flea Market, Ham Radio, Greenville, N. H. 03048.

NEED SCHEMATIC for Sencore fields effect meter model 149 or operating service center. Can you help? Neal Perry, P. O. Box 255, Zion, Ill. 60099.

QSL'S — BROWNIE W3CJI — 3035B Lehigh, Allentown, Pa. 18103. Samples with cut catalog 35¢.

432 MHz TRANSMIT CONVERTER, VHF-UHF receive converters. Write for more information. Carmichael Communications, P. O. Box 256, Carmichael, CA. 95608.

TELETYPE EQUIPMENT FOR SALE for beginners and experienced operators. RTTY machines, parts, gears. Send us a list of your teletype needs. Atlantic Surplus Sales Co., 1902 Mermaid Ave., Brooklyn, New York 11224. Call us first (212) 266-2629.

WANTED: Someone with a 1919 or 1920 Canadian license list or some other means of proving that John R. Nesbit was licensed as 5BM at that time. Please contact VE7AS.

POLICE CALL. A complete listing including frequency and location of VHF-UHF public service stations. Nine volumes cover the whole USA. Order the volume for your state. Only $4.95 plus 25¢ shipping. HAM RADIO, Greenville, N.H. 03048.

WANTED: Diagram or manual for Supreme 504B set/tube tester. WA5ZDD, 1515 Walnut St., Vicksburg, Miss. 39180.

NEW CANADIAN MAGAZINE. "Electronics Work Shop". $5.00 yearly, sample $1.00. ETCOB, Box 741, Montreal, H3C 2V2.

WANTED: CRYPTOGRAPHY manuals, books, devices. WN2TSD, 17 Alfred Road, Merrick, New York 11566.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines in assembled or kit forms, plus many other suppression accessories. Free literature. Estes Engineering, 543-H West 184th, Gardena, California 90248.

AUCTION — Canton Amateur Radio Club, Friday, March 14, 1975 at 6:00 p.m. Check in on 52 or 19/79. Imperial House at I-77 and Easton St., Canton, Ohio.

WANTED: ARC-51, 618T1, ARC-102, etc. Have Sony TC-177SD Cassette Decks for trade. A R S Electronics, P. O. Box 34804, L. A., Ca. 90034. (213) 279-1275.

SELL: Heath SB-401, SB-301, SB-610, Mint $450. G.E. prog. line MT-13N and various strips. M. H. Klapp, 25 Gladwish Road, Delmar, N. Y. 12054.

MOTOROLA PORTABLES — Expert repairs, reasonable prices, fast turn-around time. More details and flat rate catalog FREE. Ideal Technical Services, 6663 Industrial Loop, Greendale, WI 53129.

CLEGG, SWAN, CUSHCRAFT at prices I dare not publish. Call or write WØNGS, Bob Smith Electronics, 1226 9th Ave. North, Fort Dodge, Iowa 50501. (515) 576-3886.

QSLs. SECOND TO NONE. Same day service. Samples airmailed 25¢. Include your call for free decal. Ray, K7HLR, Box 331, Clearfield, Utah 84015.

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TRAVEL-PAK QSL KIT — Send call and 25¢; receive your call sample kit in return. Samco, Box 203, Wynantskill, N. Y. 12198.

FREE BARGAIN CATALOG. LED's, transistors, IC's, Xtals, headsets, microphones, relays, micro components, misc. Chaney's, Box 15431, Lakewood, Colorado 80215.

PRINTED CIRCUIT TECHNIQUES for the hobbyist. Booklet: $2.00. H. S. steel and carbide drill bits and PC artwork. Send SASE for flyer. Trumbull, 833 Balra Dr., El Cerrito, Ca. 94530.

MINICOMPUTER for sale. DEC PDP-8L minicomputer with 4000 word by 12 bit memory, manuals, schematics, and some programs. $1500.00 or best reasonable offer. David Kohl, 3002 Bedford Ave., Brooklyn, N. Y. 11210.

TWO-METER FM ANTENNAS, 1/4; 5/8 W "CAR-TOP"; and fixed station. Unique designs. Send for literature. MARSH DEVICES, P. O. Box 154, Old Greenwich, Connecticut 06870 (h)

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ROCHESTER, N. Y. — Hamfest date of 1975 — May 31st. Marriott Inn is new headquarters. Information? Write WNY Hamfest, Box 1388, Rochester, N. Y. 14603.

TELL YOUR FRIENDS about Ham Radio Magazine.

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TRANSISTOR SOCKETS!!! three styles, 25 assorted $1.00, postpaid. CPO Surplus, Box 189, Braintree, MA 02184.

RECIPROCATING DETECTOR, write Peter Meacham Associates, 19 Loretta Road, Waltham, Mass. 02154.

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DAYTON HAMVENTION at HARA Arena, April 25, 26, 27, 1975. Program brochures mailed March 10th. Write for information if you have not attended the last two years to HAMVENTION, P. O. Box 44, Dayton, Ohio 45401.

WANTED: Old toy trains and old radios from 1920's. Also train and radio magazines and catalogs. W2GHF, 45 Allen Dr., Woodstock, N. Y. 12498.

FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada. MIS 3B4.

SELL: Staco 1520 variac, $45. Wagner Xfmr, 3.6 kVA CT with dual pri, $45. K9ZPJ, 4542 N. 105 St., Wauwatosa, WI. 53225.

QRP TRANSMATCH for HW7, Ten-Tec and others. Send stamp for details to Peter Meacham Associates, 19 Loretta Road, Waltham, Mass. 02154.

PADRE SEZ: We have a lot of goodies left over from our tremendous Rummage Sale! (Like Polarad, Collins, IR, Weston, Simpson, etc.) Transistors, diodes, parts from Uncle Sam, and oodles of noodles! From 1¢ to $1000! Send 2 stamps for free listings to Padre-K9DNR, 916 No. Western Ave., Chicago, Ill. 60622 (312-486-1086).

SURPLUS TEST EQUIPMENT, VHF and microwave gear; write for bulletins. David Edsall, 2843 St. Paul, Baltimore, Md. 21218.

WANTED SX101. HR060 coils AB, AC, and AD. Any details on modifications for SX101 and HR060. Johnson Viking matchbox 250 or 750 watt with SWR meter. State condition, with manual, and price including shipping. K9UKX, Joe Torzewski, 51625 Chestnut Road, Granger, IN 46530.

TELETYPEWRITER PARTS, gears, manuals, supplies, tape, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, Fl. 33310. Buy parts, late machines.

RTTY NS-1 PLL TU wired, tested, guaranteed $25.95 ppd., less switch, meter, power supply. Board undrilled $4.75. Nat Stinnette Electronics, Tavares, FL 32778.

MANUALS for most ham gear made 1940/65, some earlier. Send SASE for specific quote. Hobby Industry, WØJJK, Box H-864, Council Bluffs, Iowa 51501.

FREE: 12 Extra Crystals of your choice with the purchase of a new Regency HR-2B at $229. Send cashier's check or money order for same-day shipment. For equally good deals on Drake, Collins, Ten-Tec, Kenwood, Swan, Atlas, Standard, Icom, Tempo, Clegg, Genave, Midland, Alpha, Hy-Gain, Mosley, CushCraft, and Hustler, write to Hoosier Electronics, your ham headquarters in the heart of the Midwest. Become one of our many happy and satisfied customers. Write or call today for our low quote and try our individual, personal service. Hoosier Electronics, R. R. #25, Box 403, Terre Haute, Indiana 47802. (812)-894-2397.

INSTRUCTION MANUALS — Thousands available for test equipment, military electronics. Send $1.00 (refundable first order) for listing. A service of Tucker Electronics, Box 1050, Garland, Texas 75040.

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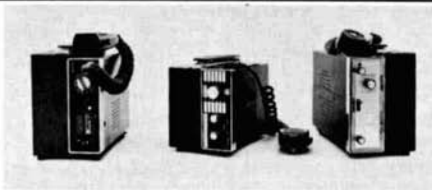

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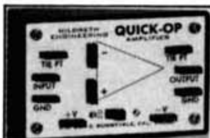

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QSL's, Sample catalog 20¢. N & S Print, P. O. Box 11184, Phoenix, Ariz. 85061.

RCA SUPERCARFONE — 6 meter FM mobile. 100W with noise blanker. 3 freq. transmit, 2 freq. receive with simultaneous monitor. Tx52.525/76/72, Rx 52.525/64, $425. WA3NDO, Henry Ciotti, 2001 Bernville Rd., Reading Pa. 19601. (215) 373-1335.

WANTED: GENERAL CLASS (or higher) hams to join 4,500 member Morse Telegraph Club. Hundreds of hams already belong. Send modest $3 annual dues (includes subscription to great slick paper newspaper "Dots and Dashes") to GST A. J. Long, 520 West Schwartz Street, Salem, Ill. 62881 for membership card and assignment to nearest chapter.

MOULTRIE AMATEUR RADIO KLUB 14th annual hamfest, April 27, Wyman Park Sullivan. Indoor, outdoor market. Tickets $1 advanced; $1.50 at gate. Write M A R K, P. O. Box 327, Mattoon, Illinois 61938.

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PC's, Send large S.A.S.E. for list. Semtronics, Rt. #3, Box 1, Bellaire, Ohio 43906.

WANTED: Sony SRA-2L Recording Amplifier. Will pay cash. Joe Reiffin, 2900 Maison Way, Sacramento, Ca. 95825.

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WANTED: tubes, transistors, equipment, what have you? Bernard Goldstein, W2MNP, Box 257, Canal Station, New York, N. Y. 10013.

THE KNIGHT RAIDERS VHF CLUB will hold their auction and flea market Sunday, March 23, 1975 at the YWCA of Paterson, 185 Carol Street, Paterson, New Jersey. Free admission, free parking, refreshments available. Talk-in 146.94 MHz. Flea market tables: $5 for full table, $3 for ½ table. Reserve your tables in advance from: Knight Raiders VHF Club, Inc., K2DEL, P. O. Box 1054, Passaic, New Jersey 07055.

WORLD QSL — See ad page 86.

LEARN DESIGN TECHNIQUES. Electronics Monthly Newsletter. Digital, linear construction projects, design theory and procedures. Sample copy $1.00. Valley West, Box 2119-C, Sunnyvale, Ca. 94087.

CANADIAN JUMBO SURPLUS and Parts Catalogs. Bargains Galore. Send $1. ETCO-HR, Box 741, Montreal "A" H3c 2V2.

STOLEN, DEC. 23, 1974: FM27B with D.A.R.T. T.T. enclosure. Ser. #27403-1624, T4X #11649, R4A #2638. Info to Gary A. Black, K8PNZ, 3872 Royal St., Berkley, Mich. 48072. 1-313-546-8859, or Det. Sgt. Flynn, Berkley Police, 1-313-541-9000.

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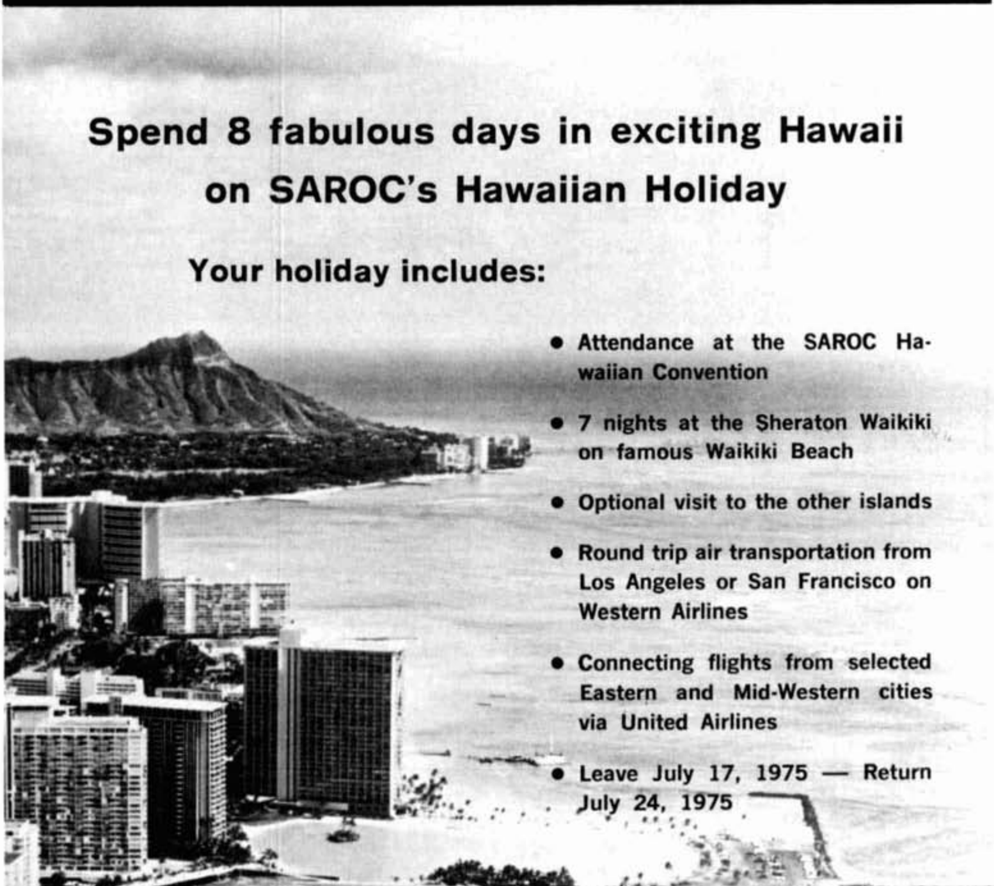

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March 1973
FEATURING: Solid-state 80-meter transceiver, reciprocating-detector receiver, AFSK generator, electronic keyers, mobile touch-tone.

June 1973
FEATURING: Digital RTTY autostart, fm repeater installation, micropower receiver, broadband amplifiers, logic oscillators.

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B & W 374 Dummy Load-Wattmeter 0-300MHz, 52Ω 0-15, 50, 300, 1500 watts ... $175.00
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Millen 92200 Transmatch ... Write
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the new TV-502 2 meter transverter

the new K-2000 full power linear amplifier

Kenwood engineering scores again. . . the TV-502 transverter now adapts any TS-520 transceiver or T-599/R-599 combination to transmit and receive SSB or CW on the two meter band.

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